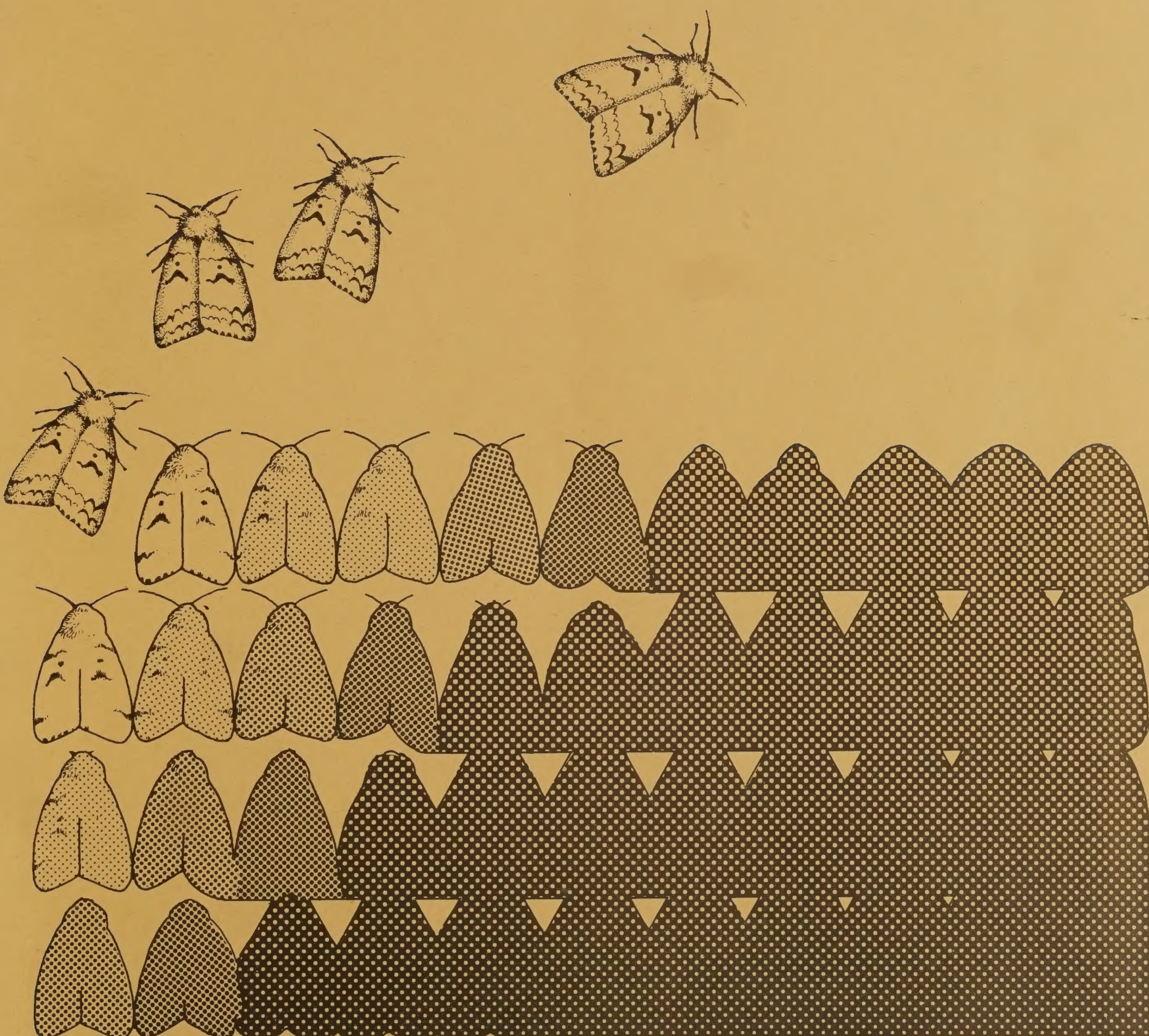
United States
Department of
Agriculture

Forest Service

Animal and Plant
Health Inspection
Service

Gypsy Moth Suppression and Eradication Projects

Draft Environmental Impact Statement



Draft Environmental Impact Statement
USDA Gypsy Moth Suppression and Eradication Projects

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Abstract: This Draft Environmental Impact Statement (DEIS) describes the proposed USDA Forest Service and Animal and Plant Health Inspection Service (APHIS) gypsy moth suppression and eradication projects in cooperation with State and Federal agencies. Four alternatives are described and evaluated: (1) no action; (2) chemical insecticide application; (3) biological insecticide application; (4) implementation of an integrated pest management (IPM) approach (preferred). The IPM alternative would integrate the use of chemical and biological insecticides and other operational technologies to suppress or eradicate gypsy moth infestations throughout the United States.

Comments on this DEIS concerning Forest Service suppression projects should be sent to Thomas N. Schenarts, Area Director, USDA Forest Service. Comments on APHIS eradication projects should be sent to Robert L. Williamson, Director, USDA Animal and Plant Health Inspection Service.

Comments must be received by _____________, 1984.

SUMMARY

DRAFT ENVIRONMENTAL IMPACT STATEMENT

USDA GYPSY MOTH SUPPRESSION AND ERADICATION PROJECTS

Purpose of and Need for Action

Since its accidental release in the United States in 1869, gypsy moth has spread throughout New England and areas to the south and west, and is now permanently established in all or parts of 14 States. Most recent additions include the eastern panhandle of West Virginia and northwestern Virginia. The gypsy moth has caused severe tree defoliation on more than 52 million acres since 1924, with 55 percent of that total or 28 million acres occurring during the period 1980-83. Single-year defoliation records were reported in 1980 (5.1 million acres) and 1981 (12.8 million acres). Individual State defoliation records were reported in 9 States in 1981. Gypsy moth defoliation subsided slightly to 8.1 million acres in 1982, and 2.3 million acres in 1983. This 2.3 million acre total is still the 4th highest defoliation since records have been maintained. Although defoliation decreased over most of the Northeast in these years, insect activity increased along the leading edge of the areas infested as the gypsy moth continued its spread in Maryland, Delaware, southern and western portions of Pennsylvania, and in an earlier established isolated infestation in central Michigan.

An increase in the number of isolated infestations resulting from the artificial movement of gypsy moth life stages to areas outside of the generally infested areas has occurred in association with the recent gypsy moth outbreak in the Northeast. In 1981, isolated infestations were treated in 9 States as far west as California. In 1982, 38 isolated infestations were treated in 14 States. In 1983, eradication treatments were applied at 37 locations in 12 States. At present, known isolated infestations of gypsy moth outside of the previosuly-mentioned generally infested areas occur in 13 States from the mid-Atlantic States and Great Lakes Region, to the West Coast.

The gypsy moth has caused dramatic economic impacts in the generally infested areas. In the 1980 report to Congress, USDA estimated losses to homewoners, forest industries, and recreation areas at $272 million. Timber losses alone in 1981 were estimated

at $72 million. Timber losses in Pennsylvania from 1970-79 were $36 million, while one State Forest in New Jersey experienced a $3 million timber loss as a result of 1979-80 gypsy moth infestations. Significant economic impacts are predicted outside of the generally infested area if isolated infestations become permanently established. A recent study conducted for the State of California predicts urban, agricultural, and forestry losses ranging between $446 million and $457 million for the period 1982 to 1999, assuming that gypsy moth infestations in the State are not treated.

Major Issues and Concerns

Major issues and concerns were identified during scoping activities. In addition, a 1983 court decision (Oregon Environmental Council vs. Kunzman et al. CA No. 82-3232, DC No. CV82-504) amplified some of these same issues. In developing this Draft Environmental Impact Statement (DEIS), USDA Forest Service and APHIS also sent letters to Federal, State, and local agencies, private industry, environmental and related groups, and interested individuals (Appendix A) asking them to identify issues and concerns.

Major issues, concerns, and opportunities identified during this entire process were: concern for human health; a need for more public education regarding gypsy moth suppression and regulatory programs; a need for increased public involvement in selection of insecticides and treatment areas; concern for the environmental effects of using insecticides; a need for discussion of alternatives to chemical insecticides; a need for continued Federal/State coordinated gypsy moth suppression and eradication projects; a need for improved and continuous communications between project coordinators regarding safety; and a need to update future National Environmental Policy Act (NEPA) documents with new information on registered insecticides such as label changes, new insecticides, and environmental monitoring.

In accordance with NEPA regulations, this DEIS will be sent for public review and comment to a variety of agencies, organizations, and individuals (Appendix B). Public comments will be considered in the preparation of the Final Environmental Impact Statement (FEIS).

Alternatives Including Proposed Action

Alternatives considered for USDA gypsy moth suppression and eradication projects on Federal and non-Federal lands are:

(1) No action.

(2) Chemical insecticide treatment.

(3) Biological insecticide treatment.

(4) IPM approach (preferred).

The no action alternative would result in no USDA-funded suppression or eradication projects. Technical assistance would be provided by USDA if requested. The no action alternative would not preclude financing and implementation of suppression and eradication projects by individual States, counties, communities, or private citizens.

The chemical insecticide treatment alternative would result in funding of proposals to use chemical insecticides such as carbaryl, trichlorfon, diflubenzuron, and acephate. These chemical insecticides have successfully achieved the desired project objectives in previous suppression and eradication projects and are registered by the U. S. Environmental Protection Agency (EPA) for application against the gypsy moth.

The biological insecticide treatment alternative would result in funding of proposals to use biological insecticides. The biological insecticides registered by the EPA for gypsy moth suppression are formulations of *Bacillus thuringiensis* (*B.t.*) and the *gypsy moth nucleopolyhedrosis* virus (NPV).

The IPM approach would result in funding of IPM strategies for gypsy moth suppression and eradication. The components of this strategy include biological and/or chemical insecticide application, parasite and predator management, application of the gypsy moth pheromone, release of sterile or partially sterile gypsy moth life stages, and forest stand manipulation. Currently, only use of the biological and chemical insecticides and the gypsy moth pheromone are considered operationally viable gypsy moth suppression or eradication components.

Affected Environment

Gypsy moth is permanently established in all or portions of Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia. Natural spread of the insect will likely continue southerly and westerly to adjacent States. Localized isolated infestations presently occur in California, Illinois, Indiana, Michigan, Minnesota, North Carolina, Ohio, Oregon, South Carolina, Tennessee, Virginia, Washington, and Wisconsin. Artificial movement of gypsy moth life

stages from the generally infested areas will continue to cause establishment of isolated infestations in these and other States where suitable host material exists; however, regulation of articles contributing to this movement will reduce such occurrences.

The areas now experiencing and those susceptible to gypsy moth are not homogenous in terms of physical, biological, economic or social attributes. Therefore, specific identification and discussion of the affected environment will be addressed in site-specific environmental analyses for proposed suppression and eradication projects.

Environmental Consequences

The no action alternative would not necessarily eliminate gypsy moth suppression or eradication activities. Nontarget organisms will not be adversely affected. Gypsy moth parasite and predator populations may increase to levels exerting some biological control of localized gypsy moth populations. If the no action alternative were implemented outside of currently regulated areas of the country, Federal and State quarantines would be imposed to limit artificial spread from these areas. If State and other Federal agencies or individuals implement their own suppression or eradication activities, the biological and physical effects would depend on the method used. Untreated infestations on Federal lands could adversely affect suppression and eradication efforts by non-Federal landowners on adjacent land. If no action is taken by State agencies or individuals, there would be no immediate impact on the physical environment except that caused by the presence of gypsy moth. Suppression projects undertaken without State coordination may not provide for adequate public involvement and notification of property owners adjacent to those residences conducting suppression or eradication activities. This could result in the application of more or less insecticide than is necessary to suppress or eradicate gypsy moth populations either of which could result in unnecessary adverse environmental effects.

Implementation of the chemical insecticide treatment alternative will, in the year of treatment, reduce gypsy moth populations, reduce larval nuisance, protect foliage, and prevent excessive tree mortality. The application of chemical insecticides will reduce populations of nontarget insects, including some beneficial insects. Diflubenzuron is toxic to some aquatic organisms. Carbaryl is toxic to honeybees, some aquatic insects, and shellfish.

Acephate is toxic to some nontarget organisms and honeybees immediately after treatment. Trichlorfon is toxic to flies, including some gypsy moth parasites. These insecticides will be applied in accordance with EPA-approved label directions. There appears to be no substantiated medical evidence showing that the chemical insecticides as used in gypsy moth suppression or eradication projects have a significant adverse impact on human health when used in compliance with the pesticide label, except in isolated circumstances where individuals exhibit extreme sensitivity to pesticides or other chemical or environmental substances. Chemical insecticides used for gypsy moth suppression and eradication projects have a relatively short residual life in soil and water. Implementation of the chemical insecticide treatment alternative will not result in any irreversible or irretrievable adverse environmental impacts.

Implementation of the biological insecticide treatment alternative can be expected to provide foliage protection, population reduction, and have no adverse effect on nontarget organisms, except some lepidopterous larvae. The only biological insecticide currently available for gypsy moth suppression and eradication are formulations of *B. t.* There will not be a direct loss of existing parasite or predator populations in areas treated with *B. t.*; however, some nontarget lepidopterous larvae may be affected. Recently, single applications of *B. t.* have demonstrated effectiveness in suppression projects; however, multiple applications of *B. t.* (2 or more) may be required to achieve project objectives in some areas where gypsy moth populations are extremely high or where eradication is the goal. The biological insecticide derived from the gypsy moth nucleopolyhedrosis virus (NPV), although registered for use, has not demonstrated the consistent efficacy required for operational use. Although the biological insecticides can provide foliage protection, larval mortality does not occur rapidly. Consequently, larval nuisance and tree defoliation are likely to continue for several weeks after application. Implementation of the biological insecticide treatment alternative will not result in irreversible or irretrievable adverse environmental impacts.

Implementation of the IPM alternative would result in the use of biological and/or chemical insecticides, the gypsy moth mating disruption pheromone, and other operationally available

suppression and eradication methods in an integrated approach. The biological effects of the IPM alternative will depend on the extent to which the various components are implemented. The IPM approach encourages the selection of either biological and chemical insecticides or other control methods commensurate with treatment needs and land management objectives. In terms of foliage protection and population reduction, the IPM alternative may result in a greater degree of tree defoliation and/or higher gypsy moth population in some areas than what could be realized under the chemical insecticide and/or biological alternatives. In some situations, quarantines may be necessary to limit artificial spread from such areas. Economic efficiency for IPM may be less than for the chemical and/or biological insecticide alternatives depending on the extent to which various IPM components are implemented.

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INTRODUCTION

This Draft Environmental Impact Statement (DEIS) describes four alternatives developed by USDA Forest Service (FS) and Animal Plant Health Inspection Service (APHIS) for suppressing or eradicating gypsy moth infestations on Federal and non-Federal land in cooperation with State and Federal agencies. The alternatives are evaluated and the preferred action is identified. The alternative implemented will guide USDA participation in gypsy moth suppression and eradication projects. When new insecticides, technology, or application methods are developed, or when environmental analyses identify unreasonable adverse effects to human health or the environment, appropriate action will be taken.

Decisions concerning USDA Forest Service and APHIS participation in suppression and eradication activities will be based on the results of site-specific environmental analyses conducted in accordance with the National Environmental Policy Act (NEPA).

PURPOSE AND NEED FOR ACTION

BACKGROUND

The Situation

The gypsy moth, Lymantria dispar L., is native to many areas of Europe, Asia, and Africa. This insect was accidentally released in the United States in 1869 in Massachusetts. In 1924, only 3 States reported the presence of gypsy moth defoliation; however, by 1983 gypsy moth defoliation had been reported in 12 States. Of concern is the total cumulative defoliation recorded since 1924 (52 million acres), particularly the recent rapid increases as depicted in the following tabulation:

Period	Total Defoliation (acres)	Percent of Cumulative Total
1924-69	11,955,486	23
1970-79	11,640,705	22
1980-83	28,432,673	55

A summary of gypsy moth defoliation by State from 1924 to 1983 is presented in Table 1.

The current gypsy moth outbreak began in 1980 when more than 5 million acres were defoliated in the Northeastern States and Michigan. This represented a record in defoliated acres, more than 2.5 times the previous high total observed in 1971. Gypsy moth activity increased dramatically in 1981 and caused tree defoliation on more than 12.8 million acres. New state defoliation records were reported that year in Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New Hampshire, Pennsylvania, and Rhode Island. Insect activity declined slightly in 1982, causing defoliation on 8.1 million acres. Although defoliation levels decreased over most of the Northeast that year, insect activity was particularly brisk along the leading edge of the infestation as the gypsy moth continued its spread in Maryland, Delaware, southern and western portions of Pennsylvania, and in an earlier established infestation in central Michigan.

An apparent natural collapse of gypsy moth populations began throughout much of the Northeast in 1983 as defoliation levels dipped to slightly more than 2.3 million acres (the 4th highest level of defoliation recorded). The insect, however, accelerated its activity in Maryland, Delaware, and central Michigan with all three States reporting record defoliation levels.

Table 1. Gypsy moth defoliation by State, 1924-83.

Year	ME	NH	VT	MA	RI	CT	NY	PA	NJ	DE	MD	MI	Total
1924	71	591	-	163	-	-	-	-	-	-	-	-	825
1925	-	239	-	48,321	-	-	-	-	-	-	-	-	48,560
1926	1	960	5	78,193	1,663	-	-	-	-	-	-	-	80,822
1927	4,985	3,923	2	131,880	126	4	-	-	-	-	-	-	140,920
1928	5,575	119,757	3	137,121	58	-	-	-	-	-	-	-	262,514
1929	15,187	440,845	-	95,078	23	-	-	-	-	-	-	-	551,133
1930	55,174	205,125	-	27,856	66	5	-	-	-	-	-	-	288,226
1931	20,938	96,690	277	86,694	114	8	-	-	-	-	-	-	204,721
1932	42,298	43,287	1	200,387	376	46	-	-	-	-	-	-	286,395
1933	19,718	216,669	2	157,003	4,292	46	-	-	-	-	-	-	397,730
1934	60,403	285,880	25	128,237	17,750	66	-	-	-	-	-	-	492,361
1935	92,630	330,195	106	106,097	10,908	833	-	-	-	-	-	-	540,769
1936	80,944	192,114	-	152,469	3,095	-	-	-	-	-	-	-	428,622
1937	140,026	72,973	81	393,613	2,063	4	-	-	-	-	-	-	608,760
1938	120,432	34,122	416	154,348	3,297	1,339	-	-	-	-	-	-	313,954
1939	202,193	136,772	5,311	143,292	848	4,224	-	-	-	-	-	-	492,640
1940	204,041	152,797	3,160	125,586	52	-	-	-	-	-	-	-	485,636
1941	122,386	80,579	980	263,369	707	-	-	-	-	-	-	-	468,021
1942	850	6,963	49	36,715	-	-	-	-	-	-	-	-	44,577
1943	10	290	-	34,481	64	-	-	-	-	-	-	-	34,845
1944	21,221	2,346	210	225,637	640	14	75	6	-	-	-	-	250,149
1945	210,881	58,517	93,950	456,832	1,280	16	-	11	-	-	-	-	821,487
1946	203,813	183,943	15,900	217,132	1,645	486	-	-	-	-	-	-	622,919
1947	-	166	-	7,256	-	-	-	-	-	-	-	-	7,422
1948	60	21	-	32,386	-	-	-	-	-	-	-	-	32,467
1949	-	8	-	78,665	-	-	-	-	-	-	-	-	78,673
1950	2	12	-	4,979	-	375	-	-	-	-	-	-	5,368
1951	8,195	2,478	1,108	3,185	-	5,673	675	-	-	-	-	-	21,314
1952	82,715	94,975	26,985	82,372	-	6,005	-	-	-	-	-	-	293,052
1953	174,999	209,335	120,787	917,996	-	56,215	7,745	-	-	-	-	-	1,487,077
1954	170,485	154,015	24,650	118,095	-	13,848	10,355	-	-	-	-	-	491,448
1955	10,810	14,975	8,875	-	-	6,842	10,559	-	-	-	-	-	52,061
1956	7,285	9,305	12,635	3,830	-	3,458	6,645	-	-	-	-	-	43,158
1957	120	-	495	16	-	4,909	858	60	-	-	-	-	6,458
1958	-	-	-	8	-	117	-	-	-	-	-	-	125
1959	1,000	4,000	1,500	382	-	5,980	1,605	-	-	-	-	-	14,467
1960	6,350	4,600	6,132	150	-	15,000	16,490	-	-	-	-	-	48,722
1961	21,340	621	11,834	3,000	-	-	30,685	-	-	-	-	-	67,480
1962	3,998	3,390	6,292	150,000	-	83,290	61,342	-	-	-	-	-	308,312
1963	1,970	8,345	12,020	87,847	-	40,140	22,600	-	-	-	-	-	172,922
1964	-	14,509	23,523	20,787	375	98,552	97,237	-	-	-	-	-	254,983
1965	190	8,451	2,903	17,232	50	86,009	148,366	-	-	-	-	-	263,201
1966	30	20	650	500	110	15,895	34,655	-	5	-	-	-	51,865
1967	825	561	2	909	150	2,731	46,160	-	1,035	-	-	-	52,373
1968	777	5,830	-	3,925	565	16,416	47,525	60	5,025	-	-	-	80,123
1969	1,450	17,160	-	6,060	313	56,881	121,610	830	51,525	-	-	-	255,829
1970	1,080	38,525	-	6,835	1,082	368,706	416,270	10,500	129,835	-	-	-	972,833
1971	820	3,250	790	18,787	8,525	655,107	479,150	598,200	180,595	-	-	-	1,945,224
1972	40	200	4,215	20,480	22,510	513,880	177,605	404,060	226,140	-	-	-	1,369,130
1973	490	30	200	43,970	35,925	333,215	248,441	856,710	254,865	-	-	-	1,773,846
1974	860	-	-	76,903	2,120	120,980	42,350	479,590	28,102	-	-	-	750,905
1975	110	-	15	17,895	435	63,411	9,275	317,880	55,430	-	-	-	464,451
1976	-	-	1,750	29,820	7,540	9,809	26,583	732,310	57,630	-	-	-	865,442
1977	2,010	320	33,435	133,081	125	-	91,313	1,296,550	39,185	-	-	-	1,596,019
1978	4,120	725	29,756	63,042	-	3,835	500,046	452,892	204,830	-	-	-	1,259,246
1979	23,180	5,980	15,411	226,260	655	7,486	162,275	8,552	193,700	10	-	100	643,609
1980	221,220	183,999	75,094	907,075	43,830	272,213	2,449,475	440,500	411,975	-	3	5	5,005,389
1981	655,841	1,947,236	48,979	2,826,095	272,556	1,482,216	2,303,915	2,527,753	798,790	500	8,826	18	12,872,725
1982	574,537	878,273	9,864	1,383,265	658,000	803,802	825,629	2,351,317	675,985	1,265	9,162	92	8,171,191
1983	16,285	560	-	148,133	53,880	153,239	290,843	1,360,824	340,285	2,992	15,870	457	2,383,368
Total	3,616,971	6,277,452	600,378	10,841,725	1,157,813	5,313,326	8,688,357	11,838,605	3,654,937	4,767	33,861	672	52,028,864

History of Gypsy Moth Control 1/

Gypsy moth control activities have been cyclical due to the periodic increases and decreases in the gypsy moth population. Control activities have traditionally involved Federal, State, county, and local government as well as private citizens.

Inconspicuous during the first 20 years after its introduction, gypsy moth populations exploded in 1889, threatening to overrun Medford, Massachusetts. Unable to deal with the situation, local officials appealed for State assistance. The Commonwealth responded quickly and appropriated funds for control activities and for a permanent commission to carry out the work. Soon thereafter, Gypsy Moth Commissioners met with mayors of affected towns, scientists, and officials from the USDA Division of Entomology to seek advice on long-range goals and tactics. Largely at USDA urging, a policy of eradication was implemented.

The first recorded use of a chemical to control gypsy moth occurred as part of the Massachusetts eradication effort. The material was an arsenical, Paris green (Forbush and Fernald 1896). The treatment of infested trees and other foliage with Paris green was supplemented by applications of creosote to egg masses, burning of infested trees, shrubbery, and clusters of caterpillars, and banding of trees with burlap and sticky materials to either trap the larvae or prevent their ascent of the trees.

The technology of insecticide application lagged far behind scientific understanding of the problem; machines designed for spraying orchards bogged down in the rough, hilly forest terrain. By the end of the 1891 field season it was evident that Paris green could not be used to eradicate the gypsy moth. Besides poor efficacy, Paris green was often phytotoxic and was easily washed off foliage (Kirkland 1905). The inadequacies of Paris green also generated adverse public reaction.

Once again the Gypsy Moth Commission was forced to turn to the expensive and time consuming methods of gathering egg masses and using traps and sticky bands to stop the larvae. Experimental work on new insecticides continued and, while an effective eradication material was not available in 1892, bromine and chlorine were found to be useful in

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1/ Major sources of this section: USDA 1981a; Dunlap 1980.

destroying egg masses in hollow trees. In 1893, a new compound, lead arsenate, proved effective in the field (Forbush and Fernald 1896). For the next 50 years, this material was the standard insecticide the Northeast for gypsy moth control.

In 1900, funds were not appropriated by the Massachusetts legislature for the Gypsy Moth Commission and the first gypsy moth campaign ended. In the succeeding years, gypsy moth populations increased such that during the summer of 1905, insect conditions in Medford, Massachusetts, and surrounding towns were similar to those in 1889.

By 1905, the gypsy moth had spread to other States in New England, making an eradication policy impossible with the insecticides and application methodology available at the time. At this point, the USDA Bureau of Entomology became involved in gypsy moth control activities.

In this second campaign, Federal and State officials looked toward biological control, that is, the use of parasites and predators to keep gypsy moth populations below damaging levels. The USDA funded programs to import and establish natural enemies of gypsy moth in Europe, and States enthusiastically supported the European parasite expeditions. Expectations ran so high that some officials predicted that the biological program would control gypsy moth within 2 to 3 years.

By 1908, however, scientists were having doubts about biological control as an immediate and economical method to control gypsy moth populations. The establishment of gypsy moth parasites and predators was proving more difficult and expensive than had been anticipated. Little was known about the biology and habits of these insects and most parasites did not survive in the new environment. Even though some parasites were parasitizing gypsy moth, the effect was not noticeable.

Biological control eventually did prove somewhat successful. By the 1920's, parasites and predators were having an effect on gypsy moth populations--but not to the extent of providing relief from defoliation and the nuisance of larvae as originally expected. Biological control work slowed after 1911 and continued at a reduced rate until World War I and for a few years beyond.

After 1911, State and Federal agencies fell back to a selective approach, treating areas such as roadsides, parks and town-areas where gypsy moth damage would be visible. In 1922, the gypsy moth reached New York and a barrier zone along the Hudson River was established to confine the insect to New England. A strenuous attempt was made to eradicate isolated infestations outside the barrier zone.

During this period the most important control techniques involved the use of insecticides, mainly lead arsenate. The popularity of insecticides was due to many factors. First was the public's desire for a immediate solution to high, damaging gypsy moth population levels. Second, insecticides could be used without much advance planning and they had immediate, visible results. Finally, they could be used by individuals or towns without a need to coordinate activities. Chemical insecticides and improved application equipment made roadside and urban spraying economical and practical.

The barrier zone policy continued until 1938 when a hurricane apparently facilitated the spread of the gypsy moth. In the early 1940's, eradication of the gypsy moth in New England was all but abandoned, primarily because lead arsenate and existing equipment were inadequate for large-scale control efforts.

The New York barrier zone was established in part to slow the spread of gypsy moth until new control techniques and methodologies could be developed. In 1939, the insecticidal properties of a synthetic organic chemical, dichloro-diphenyl-trichloroethane (DDT), were discovered.

DDT acted as both a contact and a stomach poison; larvae not killed by contact soon succumbed following ingestion of treated foliage. Less than a pound of DDT per acre killed almost all of the larvae. Soon after DDT was available for general use, USDA officials considered ideas of complete gypsy moth eradication--the first revival of that idea since the turn of the century. By 1956 Federal and State officials had formulated an eradication plan. The first phase involved aerial application of DDT to eliminate outlying gypsy moth infestations in New York, Pennsylvania, and Michigan. The second phase would involve treatment of gypsy moth infestations in New England. At its peak use in 1957, more than 2 million acres of forest and forested communities were treated with DDT.

During the period of its use, DDT was applied to more than 12 million acres of forest in 9 Northeastern States and Michigan for gypsy moth control (EPA 1975).

In the late 1950's and early 1960's, a growing public concern developed over the use of DDT. The material was being described as a "dangerous substance which killed beneficial insects, upset the natural ecological balance and collected in the food chain, thus posing a hazard to man, and other forms of advanced aquatic and avian life" (EPA 1975). Beginning in 1958, DDT was phased out of USDA cooperative gypsy moth suppression projects. In 1972, the EPA cancelled most uses of DDT.

Since the 1950's, there has been an increase in the research and development of new insecticides. In 1958, a new material, carbaryl, under the trade name Sevin®, was introduced to replace DDT as the primary agent to control the gypsy moth. Although carbaryl has a much shorter half-life and is generally considered much safer than DDT, the material in certain formulations is highly toxic to honeybees. During the period from 1962 to 1977, almost 2 million pounds of this material were used by Federal and State agencies against the gypsy moth in the Northeastern United States.

In the late 1960's, an organophosphate, trichlorfon, registered under the name of Dylox®, proved efficacious against the gypsy moth. By the early 1970's, 2 formulations of Dylox had been used in operational gypsy moth programs. During the 1970's, another organophosphate, acephate (Orthene®) and an insect growth regulator, diflubenzuron (Dimilin®), were registered. Additional chemicals such as malathion, methoxychlor, and phosmet are registered for gypsy moth control, but they are not generally used in Federal/State suppression or eradication projects.

Insecticide research and development in recent years has not been limited to chemicals. During the 1950's, USDA began development on a bacterium that affects many lepidopterous species. This bacterium, _Bacillus_ _thuringiensis_ (_B_. _t_.) is currently registered and available under a variety of trade names. During the 1960's, the USDA Forest Service began investigations of a nucleopolyhedrosis virus (NPV) that causes a wilt disease primarily in heavy gypsy moth populations. This virus product was

refined in the 1970's and registered in 1978. It is currently undergoing field testing and is not considered ready for operational use at this time. Also in the 1970's, the USDA successfully isolated and synthesized the sex attractant emitted by female gypsy moths. This material, called disparlure, has been used almost exclusively as a detection tool for locating isolated gypsy moth infestations outside of the Northeast. Development and evaluation of the material to confuse male moths and disrupt mating is currently being conducted by Federal agencies and private industry.

Gypsy moth suppression activities have evolved from State-administered projects like those in Massachusetts in the 1890's, to current Federal/State coordinated projects. The failure of earlier policies to check the natural spread of gypsy moth caused pest managers and private citizens during the 1950's to no longer attempt eradication of the insect in the Northeast. Although gypsy moth eradication is still the goal in isolated infestations, strategies are tailored to fit the particular situation in an Integrated Pest Management (IPM) approach.

An IPM approach is possible today because of the different kinds of treatments and methodologies now available or soon to be operational. These include more refined survey methods and ability to predict population buildups and subsequent impacts. The existence of several chemical and biological insecticides allows pest managers flexibility in selecting tactics that are most effective and that have a minimal impact on the environment. As an integral part, an IPM strategy also provides for more public involvement in the selection of treatment areas and tactics.

Major Issues and Concerns

The general buildup of gypsy moth populations has focused public attention on efforts to suppress infestations and regulate spread. Major concerns of State agencies responsible for gypsy moth management and other Federal landowners are the impacts of establishment of isolated infestations, larval nuisance, tree defoliation, and tree mortality.

In developing this DEIS for gypsy moth suppression and eradication, the USDA Forest Service and APHIS sent letters to Federal, State and local agencies, private industry, environmental and related private organizations, and interested individuals (Appendix A). These groups and individuals were asked to identify relevant issues and concerns. In addition,

a 1983 court decision (Oregon Environmental Council vs. Kunzman et al, CA No. 82-3232, DC No. CV 82-504) amplified some of these same issues. The major issues and concerna identified through the public scoping process and the court cases, beginning with those most frequently mentioned, are:

(1) Human health. Concerns were express regarding the aerial application of chemical and biological insecticides to communities and adjacent populated areas in relation to direct and indirect contamination of drinking water, wells, watersheds, and garden crops. Also expressed were the potential health risks from direct and indirect human (including children and sensitive persons) exposure to insecticides, specifically with regard to the supposedly carcinogenic effects of nitrosocarbaryl, and allergies to chemical insecticides. Concerns expressed in support for suppression of the insect were related to potential allergic reactions from contact with larval hairs, larval excrement, and moth wing scales. Effects of insecticide applications on forest lands as opposed to lands without tree cover needs to be discussed.

(2) Public education. Participants expressed a need for increased education in the form of publications, newspaper articles, and films that present the gypsy moth problem in an unbiased manner; additional publications on homeowner self-help techniques and the current status of new techniques; increased use of biological insecticide and parasites; and case studies on the long-term effects of gypsy moth defoliation. In addition, respondents felt that a description of treatment areas and discussion of treatment techniques used in USDA suppression and eradication projects was necessary.

(3) Public involvement and notification. Respondents indicated a need for local involvement in the determination of project criteria and procedures based on State and local meetings and guidance; the need for improved and continuous communications between State, local, and community coordinators and the public regarding areas planned for treatment, treatment dates, cancellation of treatments, and rescheduled dates; and an explanation of plans to ensure public safety. A need also was expressed for the identification of officials responsible for

administering suppression or eradication projects and those available to the public to provide other project information.

(4) Environmental effects. Concern was expressed regarding the need to use short residual insecticides and on the effect of insecticides on gypsy moth parasites, predators, honeybees, aquatic insects, and wildlife.

(5) Alternatives to chemical insecticides (New Technologies). Respondents expressed the desire for a discussion of alternatives to chemical insecticides such as the increased use of biological insecticides, homeowner self-help techniques, and parasites and predators, and of the effectiveness and long-term benefits of these alternatives.

(6) Availability of past and current Environmental Impact Statements. Some people did not know where to obtain copies of past and current Environmental Impact Statements. A mechanism needs to be developed whereby documents can readily be obtained.

(7) Label interpretation. Participants expressed a need to update Environmental Impact Statements with information on registered insecticides; label changes, new insecticides, monitoring, and human health studies.

(8) Project administration. Requests were made for a more coordinated approach between the USDA Forest Service, APHIS, and cooperating State agencies; a new funding arrangement for cooperative suppression favoring increased application of biologicals over the chemical insecticides; and increased emphasis on IPM.

(9) Federal involvement. Most participants favored State and Federal involvement in cooperative suppression and eradication projects to provide for coordinated projects using registered insecticides applied under optimum weather conditions with proper application timing.

These issues and concerns were used to guide the environmental analysis documented in this DEIS. Issues and concerns dealing with individual projects and techniques to be used will guide site-specific environmental analyses, and be conducted in accordance with NEPA.

Economic Considerations

Economic losses resulting from gypsy moth infestations in the Northeast have been dramatic. USDA Forest Service and APHIS reported to Congress that losses to homeowners, forest product industries, and recreation areas were $272 million in 1980 (USDA 1981b). Timber losses alone in 1981 were estimated at $72 million (USDA 1982). In New Jersey and Pennsylvania, timber loss has been particularly severe in the last decade.

In one study on Stokes State Forest in northwestern New Jersey, the 1979 and 1980 gypsy moth infestations killed more than 15.5 million board feet and 145,000 cords of timber. This in effect reduced the oak growing stock on the forest by 50 percent. Economic losses on this forest alone were estimated to be more than $3 million in a State where the estimated stumpage value of forest products harvested annually is $8.6 million (NJ DEP 1982).

In another study, the Pennsylvania Department of Environmental Resources estimated timber losses in State woodlands resulting from gypsy moth infestations during the 1970's. Based on surveys of 2.2 million acres, it was estimated that more than 545 million board feet of sawtimber and 462 million cubic feet of pulpwood were lost. This represents an average stand loss of 20 percent, valued at more than $36 million (PA DER 1980).

Significant gypsy moth economic impacts are predicted outside of the generally infested area if isolated infestations are not eradicated. In a study prepared for the California Department of Food and Agriculture, Galt (1983) estimates that urban, agriculture, and forestry losses could range between $446 million and $457 million between 1982 and 1999 if isolated gypsy moth infestations are allowed to spread.

USDA PARTICIPATION

Statutory Authority

Laws applicable to the USDA Forest Service and APHIS that govern participation in suppression and eradication projects are:

(1) The Cooperative Forestry Assistance Act of 1978 (P. L. 95-313), which incorporated provisions of the Forest Pest Control Act of 1947 (now repealed), provides authority for Federal/State cooperation in forest insect and disease

management. The law recognizes that the Nation's capacity to produce renewable forest resources is significantly dependent on non-Federal forest lands. Therefore, the Secretary of Agriculture is authorized to assist in the control of forest insects and diseases on non-Federal forest lands of all ownerships to (a) enhance the growth and maintenance of trees and forests and (b) promote the stability of forest-related industries, and employment associated therewith, through protection of forest resources.

(2) The Plant Quarantine Act of 1912 as amended (7 USC 151-165, and 167); the Federal Plant Protection Act of 1957 (7 USC 150aa-150jj); and the cooperation with States in Administration and Enforcement of Certain Federal Laws approved September 2, 1963 (7 USC 450). These statutes authorize among other things the development of APHIS activities for the regulation of the artificial spread of the gypsy moth from the quarantined area, and the eradication of isolated gypsy moth infestations outside this area.

(3) The National Environmental Policy Act of 1969 (P. L. 91-190 42 USC 4321 et seq) requires detailed environmental analysis of proposed major Federal actions that may affect the quality of the human environment. Generally, the courts have regarded those State actions which involve potential environmental consequences, and for which purpose Federal funds are granted, as Federal actions (Atherton 1977).

(4) The Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (7 USC 136) as amended requires that insecticides used in suppression and eradication projects be registered by the EPA.

Agency Goals

The following USDA goals are considered in the evaluation of gypsy moth suppression and eradication projects:

(1) A principal USDA goal is to assure an adequate supply of high-quality food and fiber and a quality environment for the American people. The USDA gives special emphasis to the development and use of efficient and environmentally acceptable integrated pest

management systems. All methods, including the use of chemical pesticides, are considered in integrated pest management projects.

(2) Forest Service policy is to protect and preserve the forest resources of the Nation against destructive forest insects and diseases. Pest outbreaks will be prevented or suppressed by methods that will restore, maintain, and enhance the quality of the environment. These objectives are attained on non-Federal lands through cooperation with State foresters or equivalent State officials. Pests are suppressed directly on National Forest System lands and in cooperation with responsible officials on other Federal lands. Projects approved for cooperative financing must meet Forest Service standards for environmental, biological, and economic acceptability and must meet Forest Service Federal role criteria (FSM 3430). Approval is based on the results of an environmental analysis conducted in accordance with NEPA regulations.

(3) The goal of the APHIS/State cooperative regulatory program is two fold: to retard or prevent the artificial, long-distance spread of the gypsy moth; and to eradicate isolated infestations when detected. This is accomplished by enforcement of regulations on the movement of articles that contribute to this artificial spread. The major articles regulated are nursery plants, logs and pulpwood, outdoor household articles, firewood, and mobile homes and recreational vehicles. APHIS also is charged with detection and eradication of infestations subsequently established as a result of the artificial movement of gypsy moth life stages into unregulated areas. Only APHIS eradication projects are fully addressed in this document. Cooperation with State agencies in eradication projects is based on the availability of Federal funds, a mutually agreed upon plan of work and the results of site-specific environmental analyses conducted in accordance with NEPA. Gypsy moth surveys provide information about pest distribution that serve to guide both regulatory and eradication activities.

The present USDA Forest Service suppression goals should not be confused with eradication policies of earlier years (pre 1960's) in the Northeast. No attempt is being made to treat all of the areas infested. In fact, Federal/State suppression projects usually treat less than 10 percent of the areas infested in any given year. Parasites, predators, and natural mortality factors are being relied on to exert biological pressures on the majority of gypsy moth infestations. Treatment of localized high-value and high-use areas in suppression projects is intended to meet short-term objectives identified by cooperating State and Federal agencies. Regulatory activities (quarantines, inspections, and treatments) by APHIS, lower the risk of artificial spread of the gypsy moth.

ALTERNATIVES INCLUDING THE PROPOSED ACTION

ALTERNATIVES CONSIDERED

The alternatives presented in this DEIS meet the State and Federal suppression and eradication objectives, address issues and concerns raised through scoping activities, and adhere to USDA guidelines governing Forest Service and APHIS participation in suppression and eradication projects.

The four alternatives considered and evaluated are:

(1) No action.

(2) Chemical insecticide treatment.

(3) Biological insecticide treatment.

(4) Integrated Pest Management (IPM) approach (preferred).

Three additional alternatives were considered but eliminated from detailed study because all are still undergoing field testing and development, and as individual alternatives, none has demonstrated the effectiveness necessary for meeting gypsy moth suppression and eradication objectives. These alternatives are:

(1) Parasite and predator management.

(2) Release of sterile or partially sterile gypsy moth life stages.

(3) Intensive forest stand manipulation (silvicultural control).

Although not fully developed, these alternatives are presented and discussed as possible components of the IPM alternative (#4).

COMPARISON OF ALTERNATIVES

No Action

The no action alternative in this document means that no USDA-funded suppression or eradication projects will be conducted on State, private, or Federal lands. However, technical assistance would still be available. Isolated infestations still would be subject to regulatory action imposed by APHIS or State regulatory agencies in the form of quarantines, inspections, and some type of treatment of infested materials shipped from the quarantine areas.

Selection of this alternative, however, would not preclude some type of action taken by State, municipal, or private individuals to suppress or eradicate gypsy moth populations.

Therefore, some suppression of outbreak populations may occur within the infested Northeastern States. In addition, communities or towns may elect to finance their own suppression as may individual land owners. However, many areas that may need suppression would receive none.

Most opportunities for coordination of suppression between States and within State municipalities and townships would be lost. Depending on the overall organization of suppression efforts, communities and individual landowners may have reduced opportunities for participation in the decisionmaking process. Increased losses of timber and shade trees would be expected to occur.

Isolated infestations that remain untreated would be expected to expand through natural spread of the insect. Depending on the local environmental and physical conditions, the expansion may be rather slow or quite rapid. After untreated populations build to defoliating levels, there will be losses of shrubs, ornamental trees, and timber, and increased insect nuisance.

As impacts on timber and ornamental shade trees increase in the infested areas of the Northeast, and as the isolated infestations increase in number and size, the USDA Forest Service and APHIS will have difficulty in meeting statutory authorities contained in the Cooperative Forestry Assistance Act of 1978 and the Plant Quarantine Act of 1912, as amended.

Chemical Insecticide Treatment

The chemical insecticide treatment alternative would result in funding of proposals using chemical insecticides such as carbaryl, trichlorfon, diflubenzuron, and acephate. These insecticides have successfully achieved the desired objectives in previous suppression and eradication projects, and are registered by the EPA for application against the gypsy moth.

The chemical insecticides will meet project objectives. Because the mode of action of most of these insecticides is by contact, they take effect in a matter of hours after application, and subsequently provide a minimum of 70 percent host foliage protection, and a 90-percent reduction in the number of larvae present and residual egg

masses. Further, they can be applied over a wide timeframe during the gypsy moth larval phase and still be effective in reducing gypsy moth populations, though adequate foliage protection may not be achieved.

Implementation of this alternative will provide immediate relief from the presence of gypsy moth larvae in communities and recreation areas. Potential allergic reactions associated with larval droppings and the hairs on gypsy moth larvae will be reduced. Hazardous roadways and sidewalks caused by slipperiness from stepping on or driving over gypsy moth larvae will be minimized.

The comparative effects of registered insecticides commonly used in USDA gypsy moth suppression and eradication projects are presented in Table 2. The chemical insecticides as a group are broad-spectrum insecticides that will affect some nontarget insects in the treatment areas, including gypsy moth parasites and pollinators (especially bees). The degree to which these nontarget insects are adversely affected depends on the insecticide and particular formulation used, and mitigating measures implemented.

The Division of Agricultural Sciences, University of California, categorized the relative toxicity of pesticides to honeybees based on laboratory and field tests (Anonymous 1981). Using their categories, the chemical insecticides used in gypsy moth suppression and eradication projects ranged from highly toxic to relatively nontoxic.

For example, the insecticide formulations Sevin 80S® (carbaryl) and Orthene® (acephate) are rated as highly toxic to honeybees, with severe losses expected if used when bees are present at treatment time or within a day thereafter. The formulation Sevin 4 Oil® (carbaryl) is rated as being moderately toxic, and can be used around bees if dosage, timing, and method of application are correct, but should not be applied directly on foraging bees or to the hives. The insecticide formulations Sevin XLR®, Dimilin®, and Dylox® are rated as relatively nontoxic and can be used around bees with minimal injury.

Similarly, the persistence of the chemical insecticides in the physical environment also varies according to the individual insecticide and formulation used. However, as described in Table 2, these insecticides as a group are relatively

Table 2. Comparative effects of registered insecticides commonly used in USDA gypsy moth suppression and eradication projects.†

Characteristic	Pesticide						
	Diflubenzuron	Trichlorfon	Carbaryl	Acephate	Bacillus thuringiensis	Nucleopolyhedrosis virus	Disparlure
I. Biological Efficiency							
1. Contact poison	0	X	X	X	0	0	0
2. Stomach poison	X	X	X	X	X	X	0
3. Rapid larval knockdown and mortality	0	X	X	X	0	0	0
4. Foliage protectant 1/	X	X	X	X	X	X	0
5. Ovicidal activity	X	0	0	0	0	X	0
6. Population control	X	X	X	X	X	X	X
7. Pre-budbreak control	X	0	0	0	0	0	0
8. Mating disruption	0	0	0	0	0	0	X
II. Economic Feasibility							
1. Tolerance established on agricultural crops	X	X	X	X	0	0	0
2. Dosage lb a.i./acre	.03-.06	1.0	1.0	0.5	8-16 2/	25-125 3/	1.8 4/
3. Number of applications 5/	1/yr.	1	1	1	1+	2	1
4. Insecticide cost per acre (1983) 6/	Low	Medium	Medium	Medium	Medium	High	Medium
III. Environmental Effects							
1. Residual activity on foliage (10 days)	X	0	X	0	0	0	X
2. Half-life:							
--water (1-2 days)	X	X	X	0	X	X	0
--soil (.5-1 week)	X	X	0	X	X	X	0
3. Adverse effects on nontarget insects:							
--parasites & predators	0	X 7/	X	X	0	0	0
--pollinators	0	0	X	X	0	0	0
4. Adverse effects on wildlife as a group	0	0	0	0	0	0	0
5. Adverse effects on aquatic organisms:							
--invertebrates	X	0	X	X	0	0	0
--fish	0	0	0	0	0	0	0
6. Causes temporary territory abandonment by birds	0	X	X	X	0	0	0

1/ Foliage protection would be achieved by definition when tree refoliation was prevented.
2/ Bacillus thuringiensis may be applied at 8-16 Billion International Units per acre per application.
3/ Nucleopolyhedrosis virus is applied at 25-125 million gypsy moth potency units per acre application depending upon natural virus levels in the target area.
4/ Hercon Luretape applied at forty 2-square inch tapes/acre is equivalent to 1.8 grams disparlure/acre.
5/ Eradication treatments involve at least 2 applications.
6/ Low - \$9/acre, medium - \$9-15/acre, high - \$15/acre/application including application and administrative costs.
7/ May temporarily reduce Tachinid fly population.

† NOTE: X = observed effect

0 = no observed effect

short lived except for diflubenzuron and carbaryl, which have residual activity on foliage of at least 10 days.

Implementation of this alternative will not alleviate the concerns of individuals questioning the use of the chemical insecticides. However, the use of a public involvement and notification program can help minimize these concerns so that individuals residing in treatment areas are aware of the proposed treatment and the available scientific data regarding possible adverse human health effects.

The cost of chemical insecticides for gypsy moth suppression and eradication projects ranges from $3 to $7 per acre per application for material. Total costs, including material, pesticide mixing, loading and application, may range from $10 to $15 per acre per application depending on the chemical used, the number and size of treatment areas, and contract requirements. Cost of ground applications range up to $50 per acre or more depending on these same factors.

Biological Insecticide Treatment

The biological insecticide treatment alternative would result in funding of proposals using biological insecticides. The biological insecticides considered and evaluated during the environmental analysis were formulations of B. t. and the gypsy moth NPV. Both are registered by the EPA for application against the gypsy moth. The gypsy moth NPV, however, is currently undergoing field tests and is not ready for operational use at this time. The comparative effects of insecticides commonly used in USDA suppression and eradication projects is presented in Table 2.

The biological insecticides are considered as environmentally safe and are not known to present any risk to human health. Neither B. t. nor gypsy moth NPV has been shown to adversely affect fish, birds, mammals or most nontarget insects. However, B. t. will affect other lepidopterous larvae if they are present in project areas. The registered NPV product has a shorter residual life in the environment than naturally occurring NPV in gypsy moth populations. The biological insecticide treatment alternative best minimizes adverse impact on soil, air, and water.

The effectiveness of biological insecticides is dependent on proper application timing. Unlike chemical insecticides, biological insecticides must be ingested by gypsy moth larvae to be effective. Younger larvae (1st to 3rd instar) are much more

susceptible to the biological insecticides than are older larvae (4th instar and beyond). As a result, there is only about a 2-week optimal treatment "window" during which application of biological insecticides can be expected to achieve maximum effectiveness. Gypsy moth population reduction and host-free foliage protection can be achieved, but to a lesser extent, if the optimal treatment "window" is missed. Since biological insecticides must be ingested, it generally takes 7 to 10 days before larvae die. During this time, some insects may continue to feed to some degree and defoliate the host trees. Should application timing be too far past the optimal "window," management objectives may not be achieved. As a result, the biological insecticide treatment alternative may not provide maximum abatement of insect nuisance in some cases; however, it could alleviate some public concerns associated with the use of chemical insecticides.

Recent advances in the use of B.t. have demonstrated that, under many treatment conditions, a single application of 12 Billion International Units (BIU) per acre is as efficacious as 2 applications at 8 BIU per acre, each. This makes B.t. more economical to use than in the past. Current costs for B.t. range from $3 to $5 per acre for material. Total costs including material, mixing, loading, and application generally are under $10 per acre, depending on project size. Where more than one application of B.t. is required, total cost rises proportionally. Costs of ground application are comparable to those for the chemical insecticides.

It is estimated by USDA that gypsy moth NPV, though not operationally available at this time, would cost about the same to use as B.t. However, because NPV currently requires two separate applications, 7 to 10 days apart, total project costs are estimated to be twice that for B.t. except where more than 1 application of the latter is required.

The recent demonstrated efficacy of a single application of B.t. in suppression projects and the reduction in product costs, make B.t. economically efficient to use in some areas. This has positive implications for suppression project benefit-cost analyses.

The biological insecticide alternative would be justified where special environmental concerns have been identified, and where absolute protection of host foliage and a reduction in gypsy moth populations are not required.

Integrated Pest Management (Preferred)

The IPM alternative would result in funding of proposals to cooperating State and Federal agencies to support use of an IPM strategy for gypsy moth suppression and eradication projects. The components of this strategy include quarantines, inspections, biological and/or chemical insecticide application, parasite and predator management, application of the gypsy moth pheromone, release of sterile or partially sterile gypsy moth life stages, and forest stand manipulation.

At this time, parasite and predator management, release of sterile or partially sterile gypsy moth life stages, and forest stand manipulation are undergoing field testing and are not available for operational use.

The IPM alternative would affect the environment only to the extent that the various components are used. The impact on soil, air, and water would depend on the amount of acreage treated with chemical or biological insecticides. Impacts on soil, air and water can be further reduced by careful monitoring of gypsy moth larval populations and treating a minimum number of acres with insecticides to achieve specific goals. Areas where parasites or other natural controls are exerting adequate biological pressure on gypsy moth populations probably would not receive insecticide treatment.

An IPM approach which includes the use of both chemical and biological insecticides and other available components can be expected to achieve the objectives of gypsy moth suppression and eradication projects. In terms of foliage protection and population reduction, IPM will perform somewhat less effectively than the chemical insecticide alternative and somewhat better than the biological insecticide alternative.

The cost of implementing the IPM alternative depends upon the extent to which the various operational components are used. The cost of using biological or chemical insecticides was discussed previously. The cost of using disparlure as a mating disruptant strategy is estimated at about $20 per acre for the disparlure-treated tape applied at 20 g active ingredient per acre. Application of the tape in the grid pattern would require at least $1 to $2 per acre, unless the application was handled as a community project. The cost of aerial application of disparlure-impregnated flakes (20 g active ingredient per acre) is estimated at $20 per

acre. 2/ Determination of benefit-cost ratios for disparlure application will require additional field evaluation.

Economic information on the use of sterile or partially sterile gypsy moth life stages suggests that at the cost of current avenues being developed, it could be competitive with the use of conventional pesticides. However, it is important to point out that this approach will be economically feasible only in extremely low-level populations. The cost of implementing other IPM components is not known at this time.

MITIGATING MEASURES

Procedures, guidelines, and other measures can be implemented to mitigate nontarget effects in suppression and eradication projects that include the use of insecticides. During application, insecticide droplets can settle in nontarget areas. Potential impact in those areas as well as exposure to nontarget organisms, including humans, can be minimized by using the proper type of application equipment, proper calibration of this equipment, adherence to strict standards for site and insecticide selection, and by following the operational plan for the project, including the use of buffer strips where necessary.

State and Federal agency participation in USDA suppression and eradication projects provides for early public involvement in the selection of treatment areas, where appropriate, and mitigating measures to be used. Through public involvement and notification, individuals known to be allergic to certain insecticides can be notified and appropriate measures can then be taken to avoid exposure to that insecticide. In order that the public is aware when insecticides will be applied, persons living within all treatment areas will be notified by telephone, local newspaper, local radio, individual letter, and/or personal contact as to treatment dates. Users of public recreation areas will be notified in parks or campgrounds.

2/ Letter from A. R. Quisumbing, Health-Chem Corporation to Noel F. Schneeberger, NA, S&PF, USDA FS, dated November 2, 1983.

Potential exposure to insecticides is greatest for individuals involved in the actual mixing and application. Proper protective clothing and safety procedures will minimize any risk to individuals involved in these tasks. Safety plans will provide contingencies, such as pesticide spills and worker exposure.

Specific mitigating measures for suppression and eradication projects will be developed and subsequently implemented on a case by case basis as identified through site-specific environmental analyses, and documented in accordance with NEPA.

A general discussion of treatment area and insecticide selection considerations, application procedures, and monitoring follow. Specific methods and procedures will be identified during site-specific environmental analyses for proposed suppression and eradication projects as necessary.

Treatment Area Selection

In general, public involvement at the community, township, county, and/or State level is an integral part of the treatment-area selection process. Local news media and public meetings are used to inform, the public that financial and technical assistance for suppression and eradication projects are available.

Responding to requests from the local level, the State conducts field evaluations to determine if the proposed suppression projects meet the necessary criteria for treatment. Field evaluations of proposed treatment areas include assessment of egg mass size, numbers, and viability; previous defoliation; and land use category. Local residents decide whether or not to participate in a cooperative gypsy moth suppression project for those potential treatment areas that meet specific State criteria.

Treatment-area selection in APHIS eradication projects is tied very closely to biological evidence of where gypsy moths are present and reproducing. Highly effective adult male pheromone traps supplemented by larval traps and visual surveys for egg masses provide this biological information. These data, along with the potential for buildup and spread from such areas and environmental impact, are considered before proposing areas for eradication treatment. Cooperating agencies are advised to use the local news media and public meetings to involve the public in the development of these projects.

Treatment area selection criteria are similar for projects on Federal lands.

Insecticide Selection and Application Procedures

Where insecticides are proposed for use, specific selection for that project will be addressed in site-specific environmental analyses documented in accordance with NEPA.

The insecticide selection process considers the project objectives, environmental sensitivities of proposed treatment areas, and the biological and economic efficiency of each insecticide. In addition:

(1) the insecticide must be registered with the EPA for use on the proposed site.

(2) the method of application must conform with label specifications.

The ultimate fate of insecticides released in the atmosphere depends on the insecticide and its formulation, the type of equipment used to apply the material, and the atmospheric conditions during the time of application. The operational plan developed for specific gypsy moth suppression and eradication projects will contain measures designed to maximize insecticide deposition on the target area. Insecticides will be applied in accordance with applicable laws and regulations.

Most gypsy moth suppression and eradication projects will be undertaken using single- or multiple-engine fixed-wing aircraft, or helicopters. These types of aircraft are highly maneuverable, operate at slow airspeeds close to the tree canopy, and permit optimum control of insecticide application. Pilots can more easily identify hazards and treatment boundaries, and make the necessary insecticide shutoffs. Low-elevation application directly over treatment areas minimizes insecticide drift out of and within the target areas. In addition, observer planes can be used on projects to direct the aerial applicators to the treatment areas, to notify pilots of exclusion areas (no treatment), and to monitor delivery of the insecticide--its release from the aircraft, deposition, and drift. In this way, any mechanical problems can be identified quickly and adjustments can be made in the applications, or the project can be shut down if the insecticide is not falling in the target areas. In areas where Federal Aviation Agency regulations prohibit low-level flying, waivers can be sought to make these relatively low-level applications.

Individual treatment areas may range from several acres to several thousand acres depending on the type of project and its location (residential areas vs. forested areas). Treatment areas may include recreational sites, selected high-value forest stands, residential areas including suburban and rural residential areas with sufficient gypsy moth host-type where the insect may create a local impact, including isolated infestations. Consequently, there should be few, if any, treatment exclusion areas within most treatment areas. Treatment and exclusion areas, where appropriate, are identified on large-scale maps that will be used to orient the aerial applicators. If necessary, treatment areas can be designated with helium-filled weather balloons or some other technique that will be highly visible from the air. Treatment exclusion areas will be observed by aerial applicators during pretreatment overflights of all areas.

Insecticides will be applied only when weather conditions favor effective insecticide penetration and dispersal into the target areas. Aerial suppression and eradication projects adhere to the following general guidelines:

(1) To minimize drift, application of insecticide should be made when the wind speed does not exceed 10 mph.

(2) Generally, insecticide application should not be attempted when temperatures exceed 80°F. High temperatures can cause excessive evaporation of the insecticide suspension before it reaches the target. The amount of evaporation depends on the type of insecticide being used. Inversion layers may form in the air when temperatures rise and prevent insecticide deposition.

(3) Insecticide application will be suspended when rain is imminent. Insecticides will be applied only when the target foliage has dried sufficiently.

(4) The treatment will be suspended whenever the insecticide does not appear to be settling in the target area.

Most insecticide treatments are applied in the early morning (4:30 am to 10:00 am) and late afternoon-early evening hours (4:00 pm to 9:00 pm), as this is when atmospheric conditions generally are the most favorable for maximizing insecticide

deposition in treatment areas. Occasionally insecticide applications may continue throughout the day, so long as conditions are favorable.

Where aerial application of insecticides is not appropriate, ground equipment may be used. Specific ground application guidelines will be developed on a site by site basis in order to mitigate unacceptable environmental impacts. These specific guidelines will be identified during site-specific environmental analyses for suppression and eradication projects and conducted in accordance with NEPA.

Beekeepers in and adjacent to treatment blocks will be notified as to the time of treatment, insecticide to be used, and the availability of pollen traps if applicable. All residents or persons visiting a treatment area are notified in advance of treatment so that they may leave or stay indoors at the time of treatment depending on their personal health and desires.

Monitoring Procedures

Monitoring is a continual process taking place before, during, and after treatment application. Specific monitoring techniques used to determine gypsy moth population levels and subsequent candidate treatment areas, to evaluate proper insecticide deposition and to evaluate project efficacy are identified in the cooperating State or Federal agency proposals. In suppression projects, State and Federal cooperators usually begin the process by conducting egg mass surveys to determine treatment areas. The egg masses in selected areas may be monitored for winter survival and the effects of parasites and predators to determine if treatment still is needed. In planning eradication projects, sampling of other gypsy moth life stages is necessary to determine whether a potential low level, reproducing population exists.

During insecticide application, spray deposit cards or a similar technique can be used to check deposition and drift. Observer aircraft may be used during aerial insecticide applications to monitor spray dispersal. Daily weather measurements of temperature, wind speed, and relative humidity generally are made on site, and subsequent communication with weather stations to help ensure that insecticide application is made under the proper weather conditions.

Following suppression activities, project personnel generally visit a representative sample of treatment blocks to assess larval mortality. Later in the

summer, aerial defoliation estimates will be conducted statewide. Ground estimates may be made if necessary. In the fall, egg mass counts are conducted in selected areas to measure population reduction. Because of extremely low populations found in eradication projects, treatment efficacy is monitored by larval traps and/or male moth pheromone traps.

AFFECTED ENVIRONMENT

HOST VEGETATION

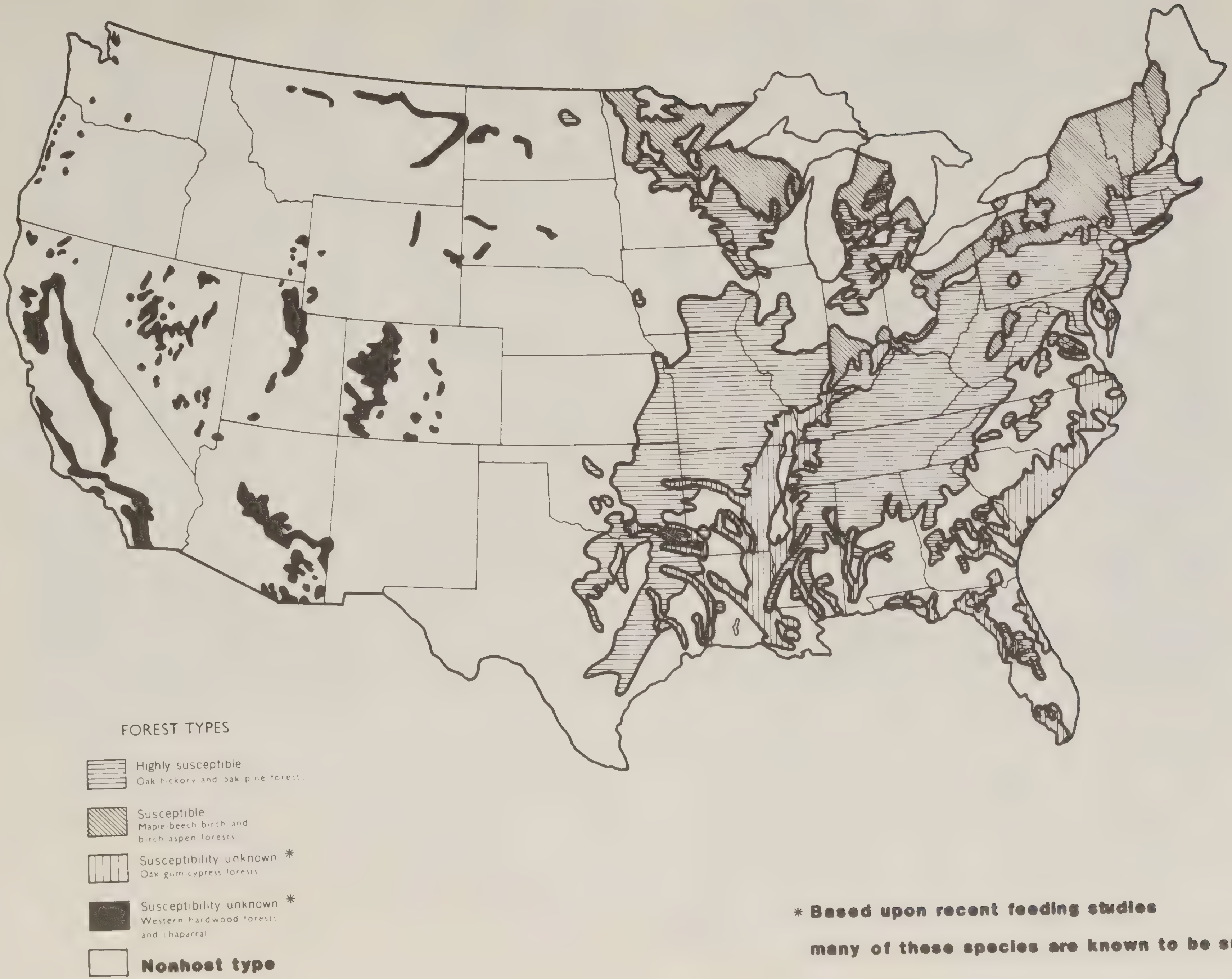
The gypsy moth feeds on more than 300 species of trees and shrubs (USDA 1981a). Figure 1 depicts the location of forest host types in the continental United States that are susceptible to gypsy moth infestation. Preferred hosts are oak species, especially white oak. Additional hosts include apple, basswood, gray and river birch, sweetgum, hawthorn, poplar, beech, willow, and other oaks. Less desired but still attacked are black birch, yellow birch, paper birch, cherry, hemlock, cottonwood, elm, sassafras, spruce, and pine. Older gypsy moth larvae feed on the foliage of several species that younger larvae normally avoid, particularly hemlock, pine, and spruce. The gypsy moth avoids ash, balsam fir, butternut, black walnut, catalpa, red cedar, flowering dogwood, American holly, locust, sycamore, tulip (yellow) poplar, and shrubs such as native laurel, rhododendron, and arborvitae. However, in outbreak situations, gypsy moth larvae will feed on almost all vegetation.

Recent gypsy moth feeding studies with late 3rd-instar larvae were conducted on plant species common to California (Edwards and Fusco 1981). Study results indicate that the following host types appear to be susceptible to gypsy moth: grand fir; acacia; red elder; apricots; manzanita; beefwood; California hazel; escallonia; eucalyptus; hakea; sweetgum; ironwood; photinia; white spruce; Norway spruce; Coulter pine; Jeffrey pine; Monterey pine; Digger pine; *Pinus halpensis*; *Pinus thunbergiana*; Douglas-fir; pyracantha; blue oak; California black oak; California white oak; cork oak; hawthorn; lemonade berry; weeping willow; redwood; western redcedar; and western hemlock. As gypsy moth populations continue to spread to the South and West, the number of plant species known to be susceptible will undoubtedly increase.

POTENTIAL TREATMENT SITES

Permanent residences occur throughout the range of vegetation susceptible to gypsy moth infestation. On private land, permanent and seasonal houses are located in suburban/urban areas, rural residential areas, and in forested areas. Entire developments and forested communities are designed and constructed to maintain a forest setting. On public lands, forested areas are developed into

Figure 1. Forest types susceptible to gypsy moth.



* Based upon recent feeding studies many of these species are known to be susceptible.

recreational areas, campgrounds, picnic areas, hiking trails, and scenic areas. Visitors include campers, canoeists, anglers, hikers, and others. Most of the recreational use is concentrated around water, scenic areas, or parks.

Gypsy moth suppression projects may be conducted in urban, suburban, or rural communities as well as in uninhabited forests. In suppression projects, individuals have the option of not participating in the proposed project to the extent allowed by State law.

APHIS eradication projects may require treatment of infestations that range from highly populated urbanized areas to rural or uninhabited sites. In addition, infested sites may range from generally open areas occupied with shrubs and those with occasional ornamental trees to highly forested communities or uninhabited forests. In all of these sites, the public involvement process will allow individuals an opportunity to provide input into the decisionmaking process. However, since the goal of the project is eradication, individuals do not have the option of having their property excluded from treatment.

NONTARGET ORGANISMS

There are many species of fish, mammals, reptiles, birds, and amphibians that inhabit the various forest types susceptible to gypsy moth infestations. Other nontarget organisms occurring in gypsy moth-susceptible host types include terrestrial and aquatic insects; pollinators, including bees needed for honey production; gypsy moth parasites and predators; and soil organisms. Some insect populations may be reduced temporarily by insecticides used for gypsy moth suppression.

Gypsy moth suppression and eradication projects are not expected to adversely affect threatened and endangered species that may be found within treatment areas. However, pursuant to the Endangered Species Act of 1973, consultation procedures will be initiated with the USDI Fish and Wildlife Service to identify any projects that may affect threatened and endangered species. Since suppression and eradication activities may take place anywhere in the United States where there are susceptible hosts, evaluations of threatened and endangered species will be addressed in site-specific environmental analyses, and conducted in accordance with NEPA.

GEOGRAPHY

Gypsy moth will continue its natural spread south and westward into States not now generally infested.

The insect is now permanently established in all or parts of the following States: Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Rhode Island, Pennsylvania, Vermont, Virginia, and West Virginia.

Because the geography and other related physical factors of these areas vary considerably, they will be addressed during site-specific environmental analyses conducted in accordance with NEPA for the particular areas proposed for treatment.

APHIS eradication projects will be conducted in areas where the insect has been introduced artificially. These artificial introductions may occur in areas throughout the continental United States and Hawaii. Treatment areas may occur in any geographic or physical setting, from low coastal to mountainous areas. Because these factors may vary considerably, they will be identified during site-specific environmental analyses conducted in accordance with NEPA for the particular areas being considered for eradication treatment.

ENVIRONMENTAL CONSEQUENCES

NO ACTION

This alternative would not necessarily eliminate gypsy moth suppression or eradication activities. State agencies, local communities, and individuals may undertake projects without Federal financial assistance. Under this alternative, the following general effects can be expected.

In the infested areas of the Northeast, if no action is taken by either State or local agencies or by individuals, gypsy moth-caused tree defoliation and subsequent mortality will occur.

Gypsy moth populations will increase and then collapse--a cycle of several years. Impacts of unimpeded gypsy moth-caused tree defoliation include tree mortality, reduced growth, and changes in forest stand composition. These effects will be dramatic in the short term and their effects will last for many years. Several case studies illustrate the point. A study by Kegg (1972a) found that 2 years of heavy defoliation in northern New Jersey in 1969 and 1970 killed 63 percent of the oaks in the study area. Stephens and Hill (1971), studying changes in Connecticut forests from 1959 to 1970, found that repeated defoliation increased oak mortality by 50 percent.

A reduction in radial growth also is associated with defoliation by forest insects (Kulman 1971). In Europe, reductions of 15 to 67 percent were observed following severe gypsy moth outbreaks (Mirkovic and Miscevic 1960; Kondakov 1963). Similar observations have been made in the United States (House 1960; Minott and Guild 1925).

It is generally believed that gypsy moth activity tends to influence forest stand composition (Campbell and Valentine 1972; Stephens 1971). This might be perceived as being beneficial in some areas by reducing favored food hosts. However, Bess et al. (1947) stated that "frequent severe defoliation will generally create conditions highly favorable to future epidemics."

Several years of heavy gypsy moth defoliation may have an adverse impact on existing wildlife (Campbell 1979). It is logical to assume that animals that normally inhabit forests will be adversely affected by several years of gypsy moth defoliation and subsequent tree mortality.

In the infested areas of the Northeast, where there is a complex of parasites and predators, it is possible that these organisms, as well as other natural controls such as wilt disease, will eventually reduce gypsy moth populations. However, this will not occur immediately, and dramatic effects such as those discussed earlier will occur.

Streams shaded by forest trees are inhabited by aquatic plants and animals. Defoliation removes the shade from those streams, producing light and heat greater than the average to which the aquatic life is adapted. In the year of defoliation, these conditions last until the trees refoliate. Under several years of successive defoliation, such conditions, while only temporarily the first year, may become more permanent characteristics if tree mortality changes the composition of tree species.

Heavy gypsy moth populations may affect water quality and quantity. Frass excreted by larvae is considered both a nutrient dump and water pollutant. Observations on the impact of frass are scarce. Turner (1963) stated: "Heavy defoliation produces hundreds of pounds of frass which soon is washed into the water by rain. The effect on the quality of water is immediate in small reservoirs. Moreover, the nutrient elements in the frass increase the growth of algae in water, creating an additional problem of longer duration." A similar observation was reported for New Jersey reservoirs (Kegg 1972b).

Where gypsy moth defoliation and subsequent tree mortality is severe, there is less vegetation to intercept rainfall and to impede the movement of ground water. This could increase streamflow but at an added cost. Water quality might be lowered due to increased runoff of soil and soil nutrients previously held in place by vegetation now destroyed by gypsy moth. Defoliation along streams may result in increased water temperatures that not only affect existing aquatic organisms but also influence plant compositions along stream banks. While the impact of gypsy moth on soil and plants other than trees has not been studied in detail, it is known that when the forest floor is opened to unaccustomed heat and light, changes in forest soil and plant life occur (Bess et al. 1947; Kegg 1972b).

Gypsy moths invading homes can seriously affect individuals with a natural fear of insects. Some individuals actually have cut down all trees on their property to avoid the nuisance of the insect. Others have been denied the use of summer homes during the period in which larvae are feeding.

Recent medical studies have shown that the hairs on gypsy moth larvae can cause skin rashes and welts (Shama et al. 1982; Beaucher and Farnham 1982). The intensity of allergic reactions in some individuals surprised researchers. Some individuals could not sleep at night and required injection of corticasteroids for relief after simple antihistamine and topical treatments failed (Beaucher and Farnham 1982).

Conditions experienced in Pennsylvania during the 1973 outbreak are reported in this summary (PA DER 1973):

> Carbon and Schuylkill Counties were considered by local officials to be disaster areas. The mayor of Tamaqua declared a state of emergency as caterpillars invaded the town and the water supply reservoir. Farmers in outlying areas reported corn and alfalfa being eaten. A new form of "control" was witnessed near Tamaqua as a homeowner started a fire under trees in his yard. The flame and heat did a good job on the trees as well as the gypsy moth. Signs of all descriptions appeared along Schuylkill County roadsides denouncing government officials from the local level to Washington. In some areas, housewives reported that caterpillars had invaded homes and began eating house plants. Golfers reported that putting greens were literally moving with migrating caterpillars. People on vacations checked into untreated resorts but left the next day.

Even the natural disease agents affecting gypsy moth may be unpleasant. The disease-killed larvae hang from their sheltered places on houses; their bodies rupture and the rotted fluid contents spill out, staining homes. Bacteria grow in the fluid, making the stench of a diseased population detectable from a distance.

It is difficult enough for people to live with the larvae and frass of a gypsy moth outbreak. Yet they also must endure the experience of having the trees around them stripped of their leaves in June and July. Hardwood trees losing about two-thirds of their foliage generally develop another set of leaves (refoliate), beginning about mid-July. Such leaves usually are smaller, off-color, and fewer in number than the original leaves. In addition, refoliation decreases valuable sugar reserves needed to sustain the tree through the following spring and winter.

Two important impacts resulting from defoliation are reduced benefits and enjoyment from the trees. These two impacts blend but it is convenient for this discussion to treat them as separate entities.

The direct benefits derived from trees that are in full foliage include cooling and humidifying effects, shade, reduced sound levels, privacy, and shelter from wind. These benefits often are taken for granted, and it is when the leaves are gone that many people realize clearly the benefits that trees provide.

Gypsy moth defoliation drastically alters the forest homeowner's environment. One purpose for living among trees is to enjoy them; robbed of that enjoyment by the gypsy moth, a person may experience decreased values associated with aesthetic surroundings.

In areas of heavy gypsy moth outbreaks, recreational use of the forest and one's own backyard can be curtailed severely due to the presence of larvae and their droppings. Painting of homes must be curtailed in outbreak areas as larvae stick to painted surfaces and congregate in sheltered places--under window ledges, porch roofs, door sills, and eaves. This necessitates repainting damaged areas.

Outdoors, sidewalks are avenues for migrating larvae. Individuals trying to use those surfaces step on larvae. Sidewalks become stained and caked with the remains of trampled caterpillars. Crushing them makes sidewalks both slippery and unsightly.

Larvae also migrate over driveways and roads. Vehicular traffic crushing larvae in an outbreak area can make roads slippery and dangerous, sometimes requiring highway department trucks to sand unsafe roads during July in the Northeast.

If no eradication action is taken against isolated infestations by State or local communities, gypsy moth populations, depending on local site conditions, are expected to thrive and become well established. The longer eradication action is delayed, the greater the opportunity for insect spread from the immediate site of the infestation into the surrounding area.

Regulatory action by APHIS and State agencies still would be implemented in the form of quarantines, inspections and treatment of materials and goods passing out of the quarantined area to stem the

artificial spread of the insect. However, as the infested area enlarges through natural spread of the insect, increased manpower would be needed each year to maintain the quarantine. Additional impacts are presented by Galt (1983), who discusses the potential economic effects of a no action alternative in California.

Under such conditions, gypsy moth populations in areas having susceptible host material may remain at low levels for several years. Eventually, the populations will build to outbreak levels, causing heavy defoliation of susceptible hosts and conditions similar to those described in the infested areas of the Northeast. During periods of high population levels, rapid expansion of the isolated infestations will occur as a result of natural and artificial spread of the insect. This will occur despite the regulatory actions implemented to contain the spread.

So long as no eradication or suppression action is taken by State or local agencies, anxieties concerning the use of insecticides and human health concerns would not occur. However, based on past experience, the presence of large numbers of gypsy moth larvae and associated defoliation or trees and shrubs would trigger public sentiment for nuisance abatement.

If State agencies or individuals attempt suppression, the biological effects of such would depend on the strategy used and would not differ from the effects previously discussed for each treatment alternative. However, suppression activities undertaken by individuals or communities without the benefit of coordination with a Federal/State-administered program may result in the application of more insecticide than is necessary, since most treatment financed by local communities or individuals entails the use of ground application equipment with varying rates of application.

Suppression or eradication activities undertaken by groups of residents seldom provide for involvement by, and notification of, adjacent residents or other people who might be interested in participating. Benefits derived from organizing a coordinated suppression approach, including maximized treatment efficiency and public safety, would not be achieved.

If the no action alternative results in no attempts by State, local communities, or individuals to suppress populations in infested areas, gypsy moth

populations will continue to thrive and spread by natural and artificial means throughout all susceptible host types in the United States. The rate of spread can be expected to accelerate as more and more acres of host type become naturally and artifically infested.

Impacts on timber and ornamental shade trees will increase. The USDA Forest Service and APHIS will have difficulty in meeting the objectives of their statutory authorities contained in the Cooperative Forestry Assistance Act of 1978 and the Plant Quarantine Act of 1912 as amended, with regard to the gypsy moth.

CHEMICAL INSECTICIDES

Direct studies of insecticide effects on humans, particularly children and abnormally sensitive persons are lacking in most cases except for a few involving volunteers. Therefore, small animal effects studies have been extrapolated to humans. Potential exposure and risk has been calculated for an average child weighing 55 lbs and for adults weighing about 130 lbs on the basis of complete exposure to the full concentration of spray material to be applied in a unit area. No degree of protection from the shielding effects of tree cover or other obstacles is assumed in the calculations. Based on this data, margins of safety are presented for all insecticides addressed in this document.

Because it is possible that some humans could be particularly sensitive to one or more of the insecticide formulations that may be used, and because it is not feasible to identify these individuals in advance, public notification procedures will be used to make it possible for anyone who has questions or concerns about adverse insecticide sensitivity to seek medical advice and adequate shelter that will avoid exposure during or after treatment or to leave the area to be treated until all danger of exposure has passed.

Efficacy and possible nontarget effects and risk to humans of any new insecticides that may become registered for gypsy moth control in the future will be addressed in environmental analyses conducted in accordance with NEPA for all projects for which their use may be proposed.

Acephate

General Information. Acephate, trade name Orthene®, is an organophosphate compound used as a contact and systemic insecticide. It has a cholinesterase inhibition mode of action (Chevron 1976). It is

TEXT IS CONTINUED ON PAGE 37a.

registered for use to control a broad spectrum of insects on ornamentals, trees, shrubs, and flowers

Acephate is a white crystalline solid with a very low vapor pressure ($2x10^{-6}$ mm Hg at 25°C) and a very high solubility in water (65 percent).

Fate in Environment. Laboratory studies indicate that acephate is rapidly degraded in soil, primarily due to the action of microorganisms. Field and laboratory studies have shown that acephate rapidly degrades in plants (Chevron 1973). Generally, a 5- to 10-day half-life has been noted in plants (Chevron 1973). Willcox (1973) reported that after applications of up to 0.5 lb per acre, residues in leaves and litter dropped below 0.02-ppm (the limit of detection) in 33 days.

Acephate breaks down relatively slowly in water as the rate of hydrolysis is affected by temperature and alkalinity. The half-life in water at pH 7 and 70°F is about 50 days under laboratory conditions. In natural bodies of water, degradation would be accelerated by breakdown in aquatic vegetation and microorganisms in sediment (Chevron 1975).

From kinetic reaction studies, it has been determined that about 5 to 10 percent of acephate

TEXT IS CONTINUED ON PAGE 38.

degrades into methamidophos which itself is a registered insecticide for use on certain lepidopterous larvae. Methamidophos is rapidly degraded in soil (Leary and Tutass 1968) and poses no threat for bioconcentration (Chevron 1973). The remaining acephate degrades directly into innocuous salts (Tucker 1972). No other metabolites of toxicological significance have been observed (Tutass 1968).

Toxicology. Acephate will adversely affect some nontarget insects within treatment areas. The effects on nontarget insects from an aerial application of Orthene at 0.5 lb active ingredient per acre for control of the gypsy moth were monitored up to 1 month after treatment (LOTEL 1975). It was concluded that lepidopterous larvae, dipterous larvae, and Hymenoptera--predominantly the family Formicidae--were adversely affected. The order Coleoptera was least affected while dipterous larvae showed the greatest decline in numbers. A knockdown effect observed immediately after treatment affected all orders of arthropods collected; however, populations that were depressed recovered to pretreatment levels within 1 month, and none was eliminated. Acephate has been rated as being highly toxic to honeybees (Anonymous 1981).

In 1976, acephate was applied at 0.5, 1.0, or 2.0 lb/acre on Wallowa-Whitman National Forest in Oregon. The effect of acephate spraying on brain cholinesterase activity was evaluated in 14 passerine species. All dosages caused marked, widespread, and prolonged brain cholinesterase depression in passerine birds (Zinkl et al. 1979). Also, postspray bird census data suggested that 2 species of birds may have left the area following the treatments (Richmond et al. 1979). In 1977, acephate was applied at 0.5 lb/acre on forested lands in Idaho for western spruce budworm control. Eleven avian species evaluated showed brain cholinesterase depression (Zinkl et al. 1980).

No human health problems have been demonstrated in the various field development programs in which acephate has been used. When used in accordance with label instructions, acephate poses no health hazard to persons formulating, spraying, or working in treated areas (Willcox and Coffey 1977). For example, a monitoring and medical study was conducted after several men were occupationally exposed to acephate in a plant where the material was being produced, and in a lab where large batches

were formulated (Pack 1972). Urine samples were monitored for acephate and metabolites. Concentrations up to 5 ppm were detected in the urine and no adverse health effects were observed. Effects on blood cholinesterase levels, a sensitive indicator of organophosphate exposure, were not detected.

In laboratory animals, the acute oral LD_{50} of acephate ranges from 866 to 945 mg per kilogram of body weight (mg/km). The acute dermal LD_{50} in test animals is established to be greater than 2000 mg/kg (Meister 1983). At the dose applied in gypsy moth projects (0.5 lb/AI/acre), it is calculated that an individual standing in the open and occupying 2 ft^2 of ground space could receive a maximum dermal exposure of 10.4 mg of acephate, assuming 100 percent insecticide deposition in the target area. This equates to a dermal exposure of 0.42 mg/kg for a 25 kg (55 lb) person, and 0.17 mg/kg for a 60 kg (132 lb) person. These exposure rates are, respectively, more than 4,800 times and more than 11,500 times less than the dermal LD_{50} dose. The dermal exposures received in this example are more than 2,000 times less for the 25 kg person and more than 5,000 times less for the 60 kg person than the established acute oral LD_{50} dosages. Actual exposure to acephate by persons in treatment areas will be significantly less than that calculated above if one considers the shielding effect of clothing which would further minimize skin contact with the insecticide. Oral exposure is not further considered here because of its unlikely occurrence during the proposed treatments.

It is highly unlikely the use of acephate as applied to treatment areas during gypsy moth suppression or eradication project would pose any human health hazard.

Carbaryl

General Information. Carbaryl, trade name Sevin®, is a broad spectrum organocarbamate used as a contact and stomach insecticide. In its technical grade, it is an odorless white to gray colored crystalline solid. Its melting point is 142°C, its density is 1.232 g/ml at 20/20°C, and its flammability is described by a Cleveland Open Cup Flashpoint of 193°C (Union Carbide 1968).

Since it was developed in 1956, carbaryl has become one of the most widely used insecticides. About 25 million pounds were used in the United States in 1974 (Dolinger and Fitch undated). Most of it was used in agriculture, but about 3.75 million pounds

were used around houses and in gardens. Such widespread use has prompted considerable investigation into effects which are now better understood than for most insecticides.

<u>Fate in the Environment</u>. Carbaryl is effective against members of most insect orders (Haynes et al. 1957; Barrett 1968). Insect species with more than 1 generation per year (USDA 1968) or with 1 generation with staggered development within the population often require repeated applications of carbaryl, because the chemical generally does not remain effective against the target insect for more than 1 or 2 weeks. The residue of carbaryl does have effective insecticidal property for several days after spraying. One study, showed that most saddled prominent larvae were killed within 48 hours of an application; however, larvae continued to die 8 days after spraying (Grimble et al. 1970). Skoog (1971) reported carbaryl effective at 18 days after treatment of grasshoppers. Residues of carbaryl, applied at 1 pound per acre as Sevin 4 Oil, remained high (causing 63 and 77 percent mortality in 2 groups of laboratory-reared gypsy moth larvae fed leaves from trees in a suppression area) at least 60 days after treatment. At 114 days mortality from the residues was 5 and 11 percent (Doane and Schaefer 1971).

Insecticide residues are degraded and diluted in the environment by a number of physical factors. For carbaryl, rain is a major factor in reducing residues (Union Carbide 1968). In Massachusetts, rain in excess of 1.8 inches occurred 12 to 24 hours after spraying with Sevin Sprayable®, and the original 190 ppm residue of carbaryl or its degradation product on dominant scrub oak foliage was reduced to about 15 ppm 3 days after spraying (Wells 1966). Chemical decomposition on plants is less important, and plants absorb only small amounts (Union Carbide 1968). Once carbaryl is in soil or water, however, chemical decomposition is dominant and promptly leads to less toxic degradation products.

The half-life of carbaryl residues is 3 to 4 days. Carbaryl, in a Sevin 4 Oil® formulation, was found to have a half-life of 8 to 10 days on range grasses (Fairchild 1970). On forest foliage, typical initial residues after treatment range from 30 to 100 ppm when carbaryl is applied for gypsy moth control. These decline to 5 to 20 ppm in 2 to 3 weeks (Back 1971). In Michigan, carbaryl (in that

case, Sevin 4 Oil) applied at a rate of 1 pound active ingredient per acre on maple trees showed residues of 500 ppm 1 day after spraying, 116 ppm after 8 days, 130 ppm after 15 days and 43 ppm after 35 days (Fairchild 1970). In New York, the same treatment applied to 2 mixed oak stands gave 192 and 55 ppm the day of spraying to 112 and 15 ppm 25 days after spraying (Fairchild 1970). Sampling of forest foliage may reveal excessively high or low residues in contrast to variation on row crops. This is believed due chiefly to the varied terrain and air currents likely to be found over forested areas as opposed to agricultural crop land. Regardless of initial deposit, the rate of residue loss usually is constant.

In a monitoring study of a gypsy moth suppression project in which Sevin 4 Oil was applied at 1 pound per acre, exposed soil residues dropped below the detection limit (0.2 ppm) 128 days after spraying; the last samples showing residues had been taken at 64 days. Occasional samples of forest litter at 128 days still had slight residues (up to 0.65 ppm); but for most, residues had dropped below the limits of detection (Willcox 1972).

If carbaryl is applied unintentionally over open water such as small brooks or ponds, an initial deposit of 1 ppm or less in a water depth of about 4 inches may be expected to completely degrade or disappear in 1 or 2 days (Romine and Bussian 1971; Calif. Dep. Fish and Game 1963; Lichtenstein et al. 1966). Results were similar for water treated with Sevin 4 Oil during a gypsy moth suppression project (Willcox 1972). A proportionately lower concentration would occur in deeper water. More than 1 ppm in water is required to reach an LD_{50} value for fish. In a gypsy moth study, residues of 30 ppb in water dropped to 1.5 ppb in 1 day (USDA 1964).

Karinen et al. (1967) concluded that carbaryl reaching shallow mud flats in marine ecosystems probably would be rapidly removed from water by adsorption on bottom mud. Chemical degradation then occurs, with carbaryl and 1-naphthol likely to persist in mud for 2 to 6 weeks. Carbaryl as an 80 percent wettable powder was applied at 10 pounds per acre to a mud flat at low tide, simulating application for control of oyster pests. The initial residue (10.7 ppm) dropped rapidly the first day when the tide removed carbaryl and 1-naphthol not adsorbed on mud. The toxicant in the top inch of mud declined from 3.8 ppm to 0.1 ppm 42 days later.

Carbaryl decomposes or metabolizes to several substances, of which 1-naphthol and 1-naphthyl (hydroxymethyl) carbamate are the most important (Union Carbide 1969). The relative toxicities (LD_{50}) of carbaryl and these substances to male rats are: carbaryl, 500 mg/kg; 1-naphthol, 2,590 mg/kg; and 1-naphthyl (hydroxymethyl) carbamate, more than 5,000 mg/kg. The no-ill-effect levels over a 7-day period for the same 3 substances are 125 to 250 mg/kg, 500 to 1,000 mg/kg and 250 to 500 mg/kg, respectively.

Toxicology. Application of carbaryl for gypsy moth control is likely to adversely affect some beneficial insects. However, any reduction in nontarget insects that may occur as a result of carbaryl application is temporary (Karpel 1973; Moulding 1972). Johansen (1959) reported carbaryl as highly toxic to honeybees, though different formulations of carbaryl have different levels of toxicity. The difference in toxicity is due mainly to the manner in which these formulations dry on the target foliage, which, in turn, determines how readily the insecticide can be picked up by honeybees and transported to the hive. Apiaries can be protected by taking precautionary measures such as locating hives beyond bee-flight range until 1 week after application (Strang et al. 1968). Covering hives before treatment also can reduce losses (Morse 1972).

The use of carbaryl has no direct adverse effects on amphibians or reptiles or fish (Romine and Bussian Tompkins 1966: Willcox 1972; Pillow 1973).

During operational spraying in Maine (1.0 lb carbaryl/acre), acetylcholinesterase levels were depressed an average of 20 percent in brook trout (Salvelinus fontinalis Mitchill) and 35 percent in Atlantic salmon (Salmo salar C.) (Hulbert 1978). These depressions were detected within 24 hours of spraying and persisted throughout the sampling period (192 hours). During spruce budworm spraying in Maine (1.0 lb carbaryl/acre) in 1975, brook trout depressions ranged between 13 and 22 percent and returned to normal within 48 hours. Activity depressions in Atlantic salmon were more gradual (9 to 27 percent) and failed to return to normal within the same sample period (48 hours) (Marancik 1976).

A study of buffered streams by McCullough and Stanley (1980) during the 1979 Maine spruce budworm project indicated that feeding and

acetylcholinesterase activity of young-of-the-year brook trout were not adversely affected. Ott and Wilder (1980) studied the effects of an application of 0.75 lb carbaryl/acre on young brook trout in 1 unbuffered and 1 buffered stream in Maine. No physiological changes in brook trout were detected that could be attributed to carbaryl contamination. In addition, these workers concluded that it was extremely unlikely that streams accidentally contaminated by carbaryl during spraying for spruce budworm control in Maine would have resulted in fish mortality.

Some aquatic insects in the orders Plecoptera (stoneflies) and Ephemeroptera (mayflies) are known to be highly sensitive to low levels of carbaryl. Trichoptera (caddisflies) and Diptera (true flies) also are sensitive to carbaryl. There may be a 50 to 100 percent reduction in aquatic insect populations in treated streams and ponds (Burdick et al. 1960). LOTEL (1977) reported that in a stream treated with 1.0 lb carbaryl/acre, each sampling station recorded a residue of at least 40 ppb and a peak residue to 80 ppb. The biological impact was indicated by increased drift of dead and dying stoneflies, mayflies, caddisflies, and true flies.

The effects of 2 consecutive years of spraying on other aquatic organisms appear similar to those observed in areas treated just once (Trial 1978, 1979; Courtemanch and Gibbs 1979). These effects include loss of stonefly species from individual streams, and altered generic assemblages for an indefinite period (Trial 1978, 1979). A study of buffered streams by McCullough and Stanley (1980) during the 1979 Maine spruce budworm spray project indicated that benthic invertebrate fauna were not adversely affected. Also, the numbers of drifting invertebrates were substantially lower than in previous years. The amount of long-term impact appears to be a function of species susceptibility and recolonization ability. Two consecutive years of spraying with carbaryl reduced populations of stonefly and susceptible mayfly genera to near zero.

Carbaryl lowers the cholinesterase levels in many animals. Cholinesterase splits acetylcholine, the chemical responsible for forming the bond necessary to carry an impulse through the nervous system. If the acetylcholine is not split, the impulse is repeated again and again, and a severe lowering of cholinesterase will result in symptoms of nerve poisoning.

Depressed brain acetycholinesterase activity of forest birds was reported following application of 1.0 lb carbaryl per acre in Montana (Zinkl et al. 1977), while split treatments (0.31 and 0.69 lb carbaryl per acre) in Maine revealed no depression (Gramlich 1979). Observations by Connor (1960) on 49 species of birds exposed to carbaryl failed to reveal adverse effects on their behavior, conditions, or reproduction and rearing of young.

In a study of the response of breeding birds to an aerial application of carbaryl, Zinkl et al. (1979) reported no significant effects on the numbers of breeding birds, nesting success, mortality rates, or activities of brain cholinesterase. An indirect effect of carbaryl spraying to birds may be a depletion of available food, which alters bird activity (Doane and Schaefer 1971).

Harry (1977) compiled an extensive review of human exposure to carbaryl. Despite almost universal exposure in the United States over more than 20 years, it seems that the safety record of carbaryl is almost unparalleled by any other insecticide.

The acute oral LD_{50} and the acute dermal LD_{50} of carbaryl has been established in test animals. The acute oral LD_{50} is 500 to 850 mg per kilogram of body weight (mg/kg) and the acute dermal LD_{50} is greater than 2,000 mg/kg (Meister 1983). At the dose applied in gypsy moth projects (1 lb AI/acre), it is calculated that an individual standing in an open area, and occupying 2 ft^2 of ground surface could receive a maximum dermal exposure of 20.8 mg of carbaryl, assuming 100 percent deposition of the insecticide in the target area. For a 25 kg (55 lb) person this equates to a dermal exposure of 0.83 mg/kg or more than 2,400 times less than the acute dermal LD_{50} dose. For a 60 kg (132 lb) person the dermal exposure would be 0.35 mg/kg or more than 5,700 times less than the acute dermal LD_{50} dose. The dermal exposures received in this example are more than 600 times less, for the 25 kg individual, and more than 1,400 times less for the 60 kg individual, than the established acute oral LD_{50} dosages. The actual exposure that an individual in a treatment area is apt to receive is significantly lower than that calculated in this example, if one considers the shielding effect of clothing which would further minimize actual skin contact with the insecticide. Oral exposure is not further considered here because of its unlikely occurrence during the proposed treatments.

In forest openings, actual dermal exposure studies conducted by the South Carolina Epidemiologic

Studies Center (1979) during Maine's spruce budworm spray project showed a total dermal exposure of 10 mg carbaryl for a person (150 pounds) who is 80 percent clothed at the time of application. In this study, the person respiratorily exposed for 2 hours in the spray area would receive only 0.054 percent carbaryl of the Time Weighted Average (TWA) standards. This equals a safety margin of 1,834 times the occupational exposure (personal communication, Ernest Richardson, Maine Bureau of Health).

In 1978 and 1979, field studies were conducted by the South Carolina Epidemiologic Studies Center to measure human exposure to carbaryl during spruce budworm suppression projects in Maine. The level of carbaryl residues found in urine samples taken during the 1978 project are shown in Table 3. The following quotations regarding 1978 results are taken from the Draft Interim Report (SCESC 1978):

> Human exposure to carbaryl applications during Maine's 1978 Spruce Budworm Suppression Project was monitored by the South Carolina Epidemiologic Studies Center. Except where there had been exposure to carbaryl from either mixing operations or home usage, none of the urine samples collected prior to application were found to contain the alpha-naphthol metabolite. Analyses of urine samples collected 12 to 24 hours after application found that the cohorts of pilots and aircraft loaders had the highest residues. About one-half of the samples from ecologists and rangers who were working and/or living in the application areas showed small but measurable levels of alpha-naphthol. Of the 49 urine samples collected from residents 12 to 24 hours after application, only 7 were positive for alpha-naphthol and ranged from 14 to 38 ppb. From the administration of health effect questionnaires, it was determined that no participant reported symptomatology thought to be related to carbaryl exposure.
>
> Data presented in the draft 1978 Maine Carbaryl Study report suggest that there were no apparent risks to those workers occupationally exposed to and individuals residing near areas aerially treated with carbaryl. Alpha-naphthol residues in the residential participants indicated that drift did not occur.

Table 3. 1-Naphthol residues in urine samples from persons exposed to Sevin 4 oil in 1978. 1/ 2/

Exposure group	Number of tested participants	Number of urine specimens tested	Number tested positive	Range of positive tests (ppb)	Median residue level of positive tests (ppb)	Average residue level of positive tests (ppb)
Pilots	5	10	10	41.00-1750.00	121.50	323.89
Loaders	5	9	8	83.00-5540.00	656.00	144.21
Ecologists	9	17	8	14.00-146.00	28.66	51.87
Wardens/ rangers/wives	11	11	5	11.11-25.00	12.14	16.85
Scouts	10	10	4	10.77-23.00	14.58	15.73
Lab technician	11	11	3	11.25-16.25	13.68	13.73
Residents	42	50	7	10.00-37.60	14.00	15.63
EPA/safety	5	6	5	23.00-1250.00	89.14	313.99

1/ Urine 1-naphthol residue analysis; lowest level detectable by this method is 10 parts per billion (ppb).

2/ From Draft 1978 Interim Report, Measurement of Exposure to the Carbamate Carbaryl: Maine Carbaryl Study, 1978. South Carolina Epidemiologic Studies Center, Medical University of South Carolina, March 1979. (Used by permission of EPA.)

Table 4. 1-Naphthol residues in urine samples from persons exposed to Sevin 4 oil in 1979. 1/ 2/

Exposure group	Number of tested participants	Number of urine specimens tested	Number tested positive	Range of positive tests (ppb)	Median residue level of positive tests (ppb)	Average residue level of positive tests (ppb)
Pilots	2	2	1	156.87		156.87
Ecologists	3	3	1	25.75		25.75
Scouts	6	6	4	10.42.17.90	12.80	13.48
Ranger/family	6	6	2	29.11-62.46	45.78	45.78
Field technician	7	7	2	14.23-187.48	100.86	100.86
Residents	16	16	5	24.00-2556.0 3/	199.40	615.97
Safety	1	1	1	3029.00 4/		3029.00

1/ Urine 1-Naphthol residue analysis; lowest level detectable by this method is 10 parts per billion (ppb).

2/ From Draft Interim Report, Measurement of Exposure to the Carbamate Carbaryl: Maine Carbaryl Study, 1979. South Carolina Epidemiologic Studies Center, Medical University of South Carolina, November 1979. (Used by permission of EPA.)

3/ The 2556.00 figure is probably due to the use of a home garden dust containing carbaryl.

4/ Twelve to 24 hours after a second intense dermal exposure.

Because of continued public concern and the need to further investigate the amount of human exposure that results from an aerial application of carbaryl, a study was conducted in 1979 by the South Carolina Epidemiology Studies Center to monitor the exposure of humans to carbaryl by measuring the urinary metabolite, alpha-naphthol, in persons potentially exposed during the aerial application to forests and to relate this exposure to air sampling. Results of 1979 urine residue analyses are shown in Table 4. The following quote regarding results of this work is from their draft interim report (SCESC 1979):

> The National Institute of Occupational Safety and Health (NIOSH) has established a time weighted average (TWA) for occupational exposure to carbaryl. The TWA is a maximum exposure limit for occupational exposed employees based on a 10-hour work shift, 5 mg/m³. The TWA, when compared to the air sampling results of the Washburn area, indicates that the residents located 0.6 miles north of spray block 6-14 were exposed to carbaryl concentrations in the magnitude of thousandths of one percent of the permissable occupational level. The highest reported level of carbaryl equivalent was found at Site 1 during the first 12 hours of sampling after application. This level (341.0 ng/m³) when converted to milligrams equals 0.0003 mg/m³ or 0.006 percent of the TWA standard. Thus the exposure of residents to carbaryl concentrations in environmental air throughout the sample period was the smallest fraction of allowable levels mandated for more intensive occupational exposure.

In the 1979 study, individuals who remained indoors during a nearby application of carbaryl were found to have no detectable alpha-naphthol, a metabolite of carbaryl, in their urine with the exception of one person who may have been previously exposed to another source of carbaryl or the insecticide malathion. Persons outdoors at the same location were found to have detectable levels. The same study indicated that persons entering spray blocks more than 24 hours after carbaryl application probably would have a 5 percent or less chance of receiving detectable exposure to carbaryl (personal communication, Dr. Sandifer, South Carolina Epidemiologic Studies Center).

In 1978 the New Jersey Department of Health, Epidemiologic Studies Program-Pesticides, monitored

people residing in gypsy moth treatment areas. The study site consisted of approximately 23 acres of heavily wooded residential land containing approximately 80 dwellings. Following carbaryl application, researchers were unable to detect the presence of a metabolic indicator of carbaryl in the urine of homeowners residing in the treatment area. By contrast, pesticide mixing and loading personnel exhibited levels of the indicator metabolite. However, a study of carbaryl formulators, conducted by the New Jersey Epidemiologic Studies Program during 1967-73, found no relationship between excessive and long-term exposure to carbaryl and chronic adverse health effects (NJESP 1974). The 1978 study further suggested that individuals who remain indoors during insecticide application receive no measurable exposure to the material. The report, presenting the 1978 study results as submitted to EPA, concluded that the aerial application of carbaryl to communities as conducted resulted in no measurable threat to human health (Schulze 1979).

Results from the studies in Maine (SCESC 1978, 1979) and New Jersey (Schulze 1979) indicate that, while precautions can be taken to reduce the number of people exposed and the amount to which they are exposed, it is not possible to avoid exposing some people to carbaryl during the spray operation. However, the amount of carbaryl is extremely small and exposure can be further minimized by remaining indoors or outside of the treatment areas during application.

Acute toxicity to people is rarely a problem with carbaryl. Comer et al. (1975) reported that plant workers producing carbaryl are exposed dermally to average levels of 73.9 mg/hr and respiratorily to 1.1 mg/hr of work. Urine samples of plant workers had concentrations of 8.9 ppm 1-naphthol, a metabolite of carbaryl, with average excretion rates of 0.5 mg/hr. In the same study, the exposure levels of spray applicator workers were studied. Average carbaryl levels were 59 mg/hr dermally and 0.09 mg/hr respiratorily. Comer et al. (1975) concluded that at these dose levels, concerns about acute toxic effects are minimal. Controlled human studies with carbaryl have been conducted at dosages sufficient to cause significant adverse effects. One investigation showed that a daily administration of carbaryl to human volunteers at 0.06 and 0.13 mg/kg/day for 6 weeks caused only slight signs and symptoms attributable to the insecticide (Wills et al. 1969).

Carbaryl is not a chronic poison. Test animals can tolerate a substantial percentage of an acutely toxic dose in the diet daily for a lifetime. Levels causing no significant effect are as high as 400 ppm dietary to the mouse, equal to 60 mg/kg body weight daily, or 200 ppm to the rat, equal to 10 mg/kg (personal communication, R.C. Back Union Carbide Agricultural Products Company). Taking the lesser of the foregoing, 10 mg/kg would calculate to a daily lifetime intake of 250 mg for a 25 kg individual and 600 mg for a 60 kg individual. Using the example presented earlier, a person standing in the open and dermally exposed to a carbaryl application (1 lb AI/acre) could potentially receive 20.8 mg of carbaryl. This is 12 times less exposure for a 25 kg person and 28 times less exposure for a 60 kg individual than the calculated no-effect level of the daily lifetime intake of carbaryl in test animals. Furthermore, the calculated exposure to carbaryl in gypsy moth projects does not occur daily.

There is some evidence suggesting that carbaryl may have teratogenic potential (causes birth defects). In a study with mice, Innes et al. (1969) showed effects at 5 mg/kg/day of body weight, which probably was about 14.2 ppm (Dolinger and Fitch, undated). The lowest dose that caused teratogenicity in dogs (Smalley et al. 1968) was 6.25 mg/kg/day or 17.8 ppm per day in the diet; no effect was observed at 3.25 mg/kg/day or 8.9 ppm. A 25 kg individual in gypsy moth treatment areas could potentially receive a dermal exposure 4 times less than the dietary no-effect level in dogs. A 60 kg individual could potentially receive a dermal exposure 9 times less than the dietary no-effect level in dogs. Once again this is a dermal exposure, and it is not received every day, unlike the feeding studies.

The question of potential teratogenic effects in humans is addressed in a letter dated May 16, 1979, from Mr. Douglas D. Campt, Director of Registration Division, EPA, to Mr. William M. Cranston (now retired), N.J. Department of Agriculture. The letter includes the following statement:

> Since experimental exposure to carbaryl has caused birth defects in dogs, carbaryl may have some potential to do so in humans, and the Environmental Protection Agency is currently attempting to assess that potential. However, since a teratogenic study of carbaryl in rhesus monkeys was negative, it would appear that the teratogenic potential in humans, if any, is not

great. One can never conclude that risk from exposure to any chemical is zero, and it is only reasonable and prudent to suggest that women who may be pregnant should avoid any unnecessary exposure to carbaryl and other chemicals. This is easily accomplished in the use of carbaryl by remaining indoors or under suitable cover at the time the application is made. Once the spray settles, any further potential for exposure is greatly reduced, and should be of no concern.

The carrying agent and emulsions of the Sevin 4 Oil formulation, as with other insecticides, are a trade secret. However, investigations have shown that the formulation contains no significant quantities of polynuclear aromatics which are compounds suspected of being carcinogenic. Nonionic polymers of polyoxyethylene ethers and nonyl phenol substances, which have been implicated in Reye's Syndrome, are not present.

The question of viral potentiation of Sevin 4 Oil recently was studied by two University of Maine researchers. Their data suggest that viral potentiation may be associated with exposure to Sevin 4 Oil. The Maine Bureau of Forestry appointed a panel of medical experts to review this study and to make recommendations concerning the potential health effects of Sevin 4 Oil. They concluded that Sevin 4 Oil poses a "potential but inconclusive health risk" and recommended that the Maine Bureau of Forestry develop more stringent limitations so that "no uninformed or unconsented human exposure will occur during a forest spray operation." A followup study was undertaken to determine the component of the Sevin 4 Oil constituents that may be viral enhancing. The data indicate that the active ingredient, carbaryl, is responsible for the viral enhancement. The medical advisory panel reviewed these new findings and felt that the original recommendations were still valid.

Under laboratory conditions, carbaryl has been reacted with nitrite compounds in the presence of an acid catalyst and heat, to form N-nitrosocarbaryl. This laboratory synthesized N-nitrosocarbaryl has been used in several laboratory test systems to demonstrate its potential mutagenic properties. Such diverse test systems as microorganism bioassays, cell cultures, bone marrow, and transplacental host-mediated trials have been conducted (Uchiyama et al. 1975; Elespuru and Lijinsky 1973; Siebert and Eisenbrand 1974).

Stomach cancer and local sarcomas have been produced in rats when laboratory-synthesized N-nitrosocarbaryl was used in feeding studies or when subcutaneously injected (Eisenbrand et al. 1975; Lijinsky and Taylor 1976). However, repeated dermal applications failed to produce skin tumors in the same species.

Since repeated dermal exposures did not produce skin tumors, oral exposure was investigated. It is thought that oral exposure to N-nitrosocarbaryl occurs by carbaryl (in the form of residues) and sodium nitrite (in saliva or food) combining in the stomach under acid conditions. In studies with guinea pigs, the formation of N-nitrosocarbaryl was reported when sodium nitrite and carbaryl were present in the stomach (Rickard et al. 1979). However, the *in vivo* production of N-nitrosocarbaryl was less than 0.2 percent of that obtained from the *in vitro* production. Further, the low pH of the guinea pig stomach, which is similar to the human stomach, causes the N-nitrosocarbaryl to become rapidly denitrosated to form carbaryl. In other laboratory feeding studies, high levels of physically mixed nitrite and carbaryl did not produce a significant increase in tumors or other lesions in either pregnant or nonpregnant rats or the exposed progeny (Lijinsky and Taylor 1977). Other laboratory studies were conducted with rats and mice to determine the oncogenic potential of carbaryl. Significantly, these studies did not produce oncogenicity attributable to carbaryl even though many were conducted at or near the maximum tolerated dose for up to 2 years. N-nitrosocarbaryl can cause mutagenic and carcinogenic effects. When found in the living body, it is unstable and the quantity is insufficient to cause carcinomas as demonstrated by these studies. The EPA review of the nitrosocarbaryl issue is presented in Appendix C.

Following an extensive review of available studies relating to the insecticide carbaryl, the EPA has concluded that further restrictions of pesticide products containing carbaryl were not warranted. A summary of that decision is presented in Appendix D of this DEIS. It is highly unlikely that the use of carbaryl, as applied to treatment areas during gypsy moth suppression or eradication projects would pose a human health hazard.

Diflubenzuron

General Information. Diflubenzuron, trade name *Dimilin®*, acts as an insect growth regulator by

interfering with the synthesis of chitin, a protein found in the body wall of insects. The primary effect is by ingestion, but there is minimal contact action. Diflubenzuron slowly acts during the gypsy moth larval stage causing the body wall of the insect to rupture during the molting phase. The current EPA label interpretation restricts the use of Dimilin 25W® --the formulation of diflubenzuron used for gypsy moth control--to forested areas with 1 house or less per 10 acres. Diflubenzuron also is registered for control of cotton boll weevil, several insects on soybeans, and mosquito larvae.

It is a white crystalline solid almost insoluble in water (about 0.2 ppm) and apolar solvents. In most polar to very polar solvents the solubility is moderate to good.

Fate in Environment. Diflubenzuron is rapidly degraded (3 to 4 days) in soil. The degradation was unrelated to soil type but was very much dependent on both the microbial activity in the soil and the particle size of the diflubenzuron (Willcox and Coffey 1978). Studies at Brigham Young University (Pintar et al. 1975) showed that all soil bacteria could utilize diflubenzuron as a sole carbon or sole carbon and nitrogen source.

The persistence of diflubenzuron in water and soil-water systems is, as with soil alone, related to the microbial activity and the particle size of the material applied. With agricultural soils, the half-life in hydrosoils is 0.5 to 1.0 weeks for the parent compound and 8 weeks for the entire radiocarbon residue (Willcox and Coffey 1978).

Toxicology. Studies have been conducted on the effects of diflubenzuron on a number of nontarget species in the forest ecosystem (USDA 1975; Willcox and Coffey 1978).

In these studies, several different forest ecosystems were treated with diflubenzuron at rates from 0.03 to 0.06 lb active ingredient per acre. Following application, soil microbes and invertebrates, terrestrial insects, aquatic insects and other nontarget crustaceans, fish, small forest mammals, and birds were monitored for the effects of treatment. No treatment-related effects were observed with elements of the soil community, including soil microbes and fungi, soil inhabiting mites, and collembolans. It was shown that diflubenzuron at the rates applied had no effect on the organisms that are involved in the degradation

and use of the forest leaf litter. In the studies of terrestrial insects, the single application of diflubenzuron had no effect on the free-flying, forest-inhabiting insects. Honeybees were unaffected when hives were placed directly within test areas. The effects monitored included honey production, egg production by the queen, and brood hatch development and survival (Willcox and Coffey 1978). Even though potential exposure to insectivorous small mammals and birds was possible, no treatment related effects were observed. Species composition and territorial distribution remained unchanged (Willcox and Coffey 1978).

Other studies have been conducted in aquatic habitats to determine the effect of diflubenzuron on aquatic insects and nontarget crustaceans (Mulla et al. 1975; Steelman et al. 1975; and Miura et al. 1975). Diflubenzuron has been found to reduce populations of certain sensitive nontarget crustaceans, primarily water fleas, cyclops and immature copepods, and certain species of aquatic insects (mayflies, corixids, and notonectids).

The effect on the aquatic environment is extremely variable and, although the species diversity in this habitat often is altered, populations of the nonsensitive forms adjust the overall community numbers to counteract the effects. Therefore, the limited environmental impact due to the nonpersistence of diflubenzuron is short lived and population recovery of the more sensitive species occurs within 14 to 28 days in most cases (Willcox and Coffey 1978).

The acute toxicity of diflubenzuron to mammals has been investigated by Phillips-Duphar B.V., Harris Laboratories, and the Huntingdon Research Center (Willcox and Coffey 1978). Because of its mode of action, the interruption of chitin synthesis on the insect, diflubenzuron has low mammalian toxicity. Diflubenzuron (40 mg technical) was shown to be a marginal eye irritant, but 50 mg in an aqueous gum tragacanth solution was not irritating. When diflubenzuron was tested for dermal effects, it was found to be nonirritating. The very low toxicity of diflubenzuron for mammalian and nonmammalian species exclusive of insects and certain chitin containing anthropods is in part related to the ability of the compound to be absorbed by the animal exposed and its ability to biochemically detoxify and eliminate diflubenzuron from its system (Willcox and Coffey 1978).

The acute oral and dermal toxicity for diflubenzuron have been established on test animals. The oral DL_{50} is greater than 4,640 mg per kilogram of body weight (mg/kg) and the dermal LD_{50} is greater than 2,000 mg/kg (Meister 1983). At the dose applied in gypsy moth projects (0.06 lb AI per acre), it is calculated than an individual standing in an open area and occupying 2 ft^2 of ground space, could receive a maximum dermal exposure of 1.3 mg of diflubenzuron, assuming 100 percent deposition of the insecticide in the target area. For a 25 kg (55 lb person, this equates to a dermal exposure of 0.052 mg/kg or more than 3,846 times less than the dermal LD_{50} dose. For a 60 kg (132 lb) person, the dermal exposure would be 0.022 mg/kg or more than 90,900 times less than the dermal LD_{50} dose. The dermal exposures received in this example are more than 89,230 times less for the 25 kg person, and more than 210,900 times less for the 60 kg person than the established acute oral LD_{50} dosages. The actual exposure that an individual in a treatment area is apt to receive is significantly lower than that calculated in this example, if one considers the shielding effect of clothing which would further minimize actual skin contact with the insecticide. Oral exposure is not further considered here because of its unlikely occurrence during the proposed treatments.

It is highly unlikely that the use of diflubenzuron, as applied in gypsy moth projects, would pose a human health hazard.

Trichlorfon

General Information. Trichlorfon, most commonly known as Dylox®, is an organophosphate chemical that is used as an insecticide and as a therapeutic drug to treat selected endoparasites in humans and livestock (Abdalla et al. 1965; Beheyt et al. 1961; Davis and Bailey 1969; Wegner 1970). Trichlorfon also is registered for use on beef and dairy cattle for the control of ectoparasites (EPA 1969). The insecticide trichlorfon is registered for use on a variety of field crops, vegetables, seed crops and ornamentals. It is effective for control of many different species of insects with contact and ingestion modes of action. Technical trichlorfon is a white crystalline solid with a specific gravity of 1.73 at 20.4°C. Solubility is 12 percent in water at 26°C and it is soluble in alcohols and ketones.

Fate in Environment. Trichlorfon is rapidly degraded in the environment. In New York (Judd et al. 1972), trichlorfon was found in small amounts in water samples collected immediately after spraying, but the concentration of the chemical dropped below

a detectable level 4 days after spraying; the half-life of trichlorfon in water at 30°C was 4.7, 0.6, and 0.1 days at pH levels of 5, 7, and 9, respectively. In this test, water was protected from light. In an outdoor pond (pH 7.0) at temperature 20°C, and with exposure to sunlight and wind, trichlorfon showed a half-life of only 0.3 day (Chemagro 1971).

Doane and Schaefer (1971) found that gypsy moth larvae that were fed leaves collected 12 days after treatment experienced only 2.5 percent mortality. After an application of 1.0 lb trichlorfon per acre in New York for gypsy moth, Weiss et al. (1973) reported that residual levels dropped sharply within a few days after treatment, and by 60 days had reached the following percentages of their initial levles: 15 in leaves, 5 in litter, 10 in unexposed soil, and less than 1 in exposed soil.

Toxicology. Trichlorfon has shown no significant adverse effects against vertebrates, birds, reptiles, amphibians, and fish (Lewallen and Wilder 1962; Pearce 1970; Chambers 1972; Caslick and Smith 1973; Finger and Werner 1973; and Todaro and Brezner 1973). Bird activity may be temporarily altered through the reduction of insects available for food (Doane and Schaefer 1971; Caslick and Cutright 1973). Trichlorfon is classified as having a low toxicity for bees (Johansen 1959). Trichlorfon residues are not transported by foraging bees from contaminated surfaces into hives (Gilpatrick and Terrill 1970).

Trichlorfon applied at dosages used for gypsy moth treatment will reduce populations of some nontarget insects, including some parasites and invertebrate predators. These nontarget insect populations recover, some within a few weeks (Chemagro 1968).

The acute oral LD_{50} of trichlorfon established in laboratory animals ranges from 150 to 400 mg per kilogram of body weight (mg/kg). The dermal LD_{50} is greater than 500 mg/kg (Meister 1983). At the dosage applied in gypsy moth projects (1 lb active ingredient per acre), it is calculated than an individual standing in an open area and occupying 2 ft^2 of ground space could receive a maximum dermal exposure of 20.8 mg of trichlorfon, assuming 100 percent deposition of the insecticide in the target area. For a 25 kg (55 lb) and 60 kg (132 lb) person, this equates to a dermal exposure of 0.8 and 0.3 mg/kg, respectively, and represents more than 600 times less (for a 25 kg person) and more than 1,440 times less (for a 60 kg. person) than

the acute dermal LD_{50} dose. The dermal exposures received in this scenario are more than 180 times less for the 25 kg person and more than 430 times less for the 60 kg individual than the acute oral LD_{50} dosages. In all likelihood, actual exposure to an individual in a treatment area will be significantly less than that calculated above, if one considers the shielding effect of clothing which would further minimize actual skin contact with the insecticide. A more realistic exposure potential is probably 75 percent less than that assumed here.

Trichlorfon has been suspected of being a mutagen in several bacteriological studies *in vitro* and *in vivo*, and teratogenic when given orally to rats. If trichlorfon is a teratogen, it does not appear to be a potent one. Staples et al. (1976) found positive results in rats, but only at high doses--432 or 519 mg/kg. Martson and Voronina (1976) found embryotoxic and teratogenic effects in rats from an 80 mg/kg dose, but none from an 8 mg/kg dose, administered during a critical period of embryogenesis. The no-effect dose level in rats is 10 and 23 times, respectively, more than the maximum dermal exposure that a 25 kg and 60 kg person could receive while standing in the open during gypsy moth projects. Oral exposure is not further considered here because of its unlikely occurrence during the proposed treatments.

It is highly unlikely the use of trichlorfon as applied to treatment areas during gypsy moth suppression or eradication projects would pose a human health hazard.

BIOLOGICAL INSECTICIDES

Two biological insecticides currently are registered for use against gypsy moth by EPA. These are the bacterium *Bacillus thuringiensis* Berliner (B. t.) and the gypsy moth nucleopolyhedrosis virus (NPV). *B. t.* is an aerobic, spore-forming, crystal-producing member of the bacterial genus *Bacillus*. NPV is a naturally occurring virus of the gypsy moth that causes polyhedrosis or wilting. Field research has been conducted and is continuing on the purification, formulation, and use of NPV. Subsequently, only various formulations of *B.t.* are currently available for gypsy moth management.

Studies on the fate of *B.t.* in the environment indicate that *B.t.* spores will persist in soil for several weeks depending on the soil type, soil flora, and on factors such as pH, moisture, and solar radiation. A study of soils treated with *B. t.* applied for vegetable pest control concluded that spores can remain viable for long periods (over

3 months), and that the organism can germinate and compete vegetatively in the soil and sporulate successfully under favorable soil conditions (Saleh 1969). The crystal is proteinaceous; degradation by the enzymatic action of soil flora can be presumed.

Survival of B. t. on leaves is minimal when no additives are included in sprays (IMC 1968). New formulations designed to protect B. t. from the ravages of environmental forces have shown considerable biological activity after 21 days of field exposure, and negligible biological activity after 1 month.

Inasmuch as B. t. is exempted from tolerance, no residue analysis on food or feed has been performed when B. t. has been used for forest-insect control (Heimpel 1971).

Laboratory-produced gypsy moth NPV has no degrading effect on the environment in which it is applied. It has a shorter residual persistence on bark and in the soil than the NPV occurring naturally in gypsy moth populations (Lewis et al. 1979).

Toxicology

Biological insecticides must be ingested by the gypsy moth larvae to be effective; therefore, no significant reduction in feeding activity or increase in larval mortality can be expected for 1 to 2 weeks after application. Recent field projects have demonstrated that a single application of B. t. at a dosage rate of 12 BIU/acre can be effective in achieving the objectives of most suppression projects. More than one application of B. t. may be needed in certain situations to achieve suppression or eradication objectives. Generally speaking, proper B. t. application can be expected to reduce gypsy moth populations by 80 percent and achieve 70 percent foliage protection. Operational use of B. t. for use in eradication projects is discussed under the IPM alternative.

The gypsy moth NPV must be ingested to be effective. Field studies continue to evaluate the effectiveness of the NPV; however, the material needs further evaluation before being used in operational projects. On the basis of field tests, proper application of gypsy moth NPV has been shown to reduce the residual number of egg masses by 75 percent, and also may reduce egg viability in the succeeding year. NPV also can be expected to achieve 50 to 70 percent foliage protection (Lewis et al. 1979).

In the formulations used for gypsy moth suppression and eradication, B. t. is a lepidoptera-specific insecticide; therefore, only insects in the Order Lepidoptera are affected by it. While lepidopterous larvae other than the gypsy moth may be affected, there will be no effect on beneficial insects such as bees (Lewis et al. 1979).

Test results reported by International Minerals and Chemical Corporation indicate that B. t. has no adverse effect on wildlife (IMC 1969). Doane and Hitchcock (1964) stated that B. t. appeared to cause negligible damage to vertebrate wildlife.

An oral acute toxicity study was conducted with B. t. on young adult bobwhite quail. The acute oral medial lethal dosage exceeded 10 gm/kg body weight (IBT 1970b). Five male and 5 female quail were fed 10 gm/kg by gavage. A similar group was fed distilled water as control. At the end of the 21-day test period, all animals were sacrificed and subjected to a gross pathological examination. No pathology attributable to the test material was found. Growth rate was similar in the test and control groups.

B. t. administered by mouth as the spore-crystal complex to rats daily for 3 months at rates of 25, 100, and 400 mg/kg produced no main function disorders or organ damage. Similar results were obtained in dogs fed 6, 25, and 100 mg/kg for 3 months (Fisher and Rosner 1959; Corlett 1961).

Fed to groups of 10 mice (16 to 25 gms.) at the rate of 10 g/kg B.t.,(Dipel®) caused no mortality. LD_{50} was beyond 10 g/kg (IBT 1970a). B.t. (Dipel) was fed to 3 female mongrel dogs at a dosage of 400 mg/kg. The animals were free of any symptoms during the 48-hour observation period (IBT 1970a).

In a test by Briggs and Goodrich (1959), 17 pheasants and 2 partridges, all about 6 weeks old, were divided into 2 groups. One group was fed 1.0 gm of B. t. per bird per day in 2 gelatin capsules. The control groups were fed 2 empty gelatin capsules daily. No deaths or symptoms of respiratory, alimentary or other disturbances were noted in the group that was fed B. t. Two pheasants in the control group died of trauma (due to handling). Birds in both groups exhibited feather color and pattern, bearing, and weight gain that are expected in similar groups of birds in nature. It was concluded that there were no differences in behavior or development between the test and control birds.

A long-term study with 6 New Hampshire Red laying hens was conducted over a 23-month period. The hens received a daily dose of B. t. ranging from 0.5 to 10 gms per bird. Results showed no allergic response, other illnesses, or variations in the expected egg production of the hens. There were no significant differences between the test birds and the birds used as controls. In a 9-week oral toxicity test administered to 24 groups of 10 chicks each, no significant differences were noted between the test and control groups of chicks (Fisher and Rosner 1959).

Eighteen humans each ingested 1 gram of Thuricide® daily for 5 days. Complete physical and laboratory examinations were given before the experiment, at the end of the 5-day ingestion period, and 4 to 5 weeks later. Physical examinations included detailed history and records of height, weight, temperature, blood pressure, respiratory rate, and pulse rate immediately after exercise and 30 and 60 seconds thereafter. Evaluations were made of genitourinary, gastrointestinal, cardiorespiratory, and nervous sytems. Lab tests included routine urinalysis with qualitative and quantitative urobilinogen determinations (when indicated), complete blood count, sedimentation rate, blood urea nitrogen, glucose, bilirubin and thymel turbidity tests. All subjects remained well during the course of the experiment. All laboratory findings were negative (Fisher and Rosner 1959).

Dermal effects of B. t. were tested by application to shaved flanks and bellies of albino rabbits. Dosages ranged from 20 percent suspensions to 50 mg/animal. After application, half of the treated skin was abraded while the other half was left intact. Readings were made at 24, 48, and 72 hours in one test and up to 3 weeks in another. Other than local, mild erythema (abnormal redness of the skin), no ill effects were noted in any test animal (Fisher and Rosner 1959; Corlett 1961). In another study, dermal application to albino rabbits was made to test allergenicity response. Ten sensitizing doses were applied every other day for 3 weeks. Readings were made 24 hours after each application of B. t. Two weeks after the 10th application, a challenge dose was applied. Only slight erythema and edema were noted. No allergenic response was elicited (Fisher and Rosner 1959). Allergenicity also was tested with guinea pigs following the procedure of Draize. No allergenic response was noted (Fisher and Rosner 1959).

Several acute toxicity tests were conducted on fish. A 4-day toxicity study was conducted with *B. t.* on rainbow trout and bluegills. Two groups of 10 fish each were placed in water containing *B. t.* at concentrations of 560 and 1,000 ppm. None of the trout or bluegills died (Fisher and Rosner 1959). Rainbow trout that were 4 inches long were exposed to *B. t.* at concentrations of 100 to 1,000 ppm for 14 days. No deaths resulted, nor were there symptoms of alimentary or behavioral disturbances evident (Fisher and Rosner 1959). In a test with juvenile coho salmon (1.6 inches long), *B. t.* was about 1/30 as toxic as DDT. The tests ran for 168 hours with concentrations of 8 to 406 mg *B. t.* per liter of water. The 48-hour median tolerance limit of the *B. t.* was about 50 mg/liter (Fisher and Rosner 1959).

Inhalation studies of *B. t.* were conducted on mice, rats, guinea pigs, and human volunteers. In one test with mice, the animals were exposed to 10 g of *B. t.* powder for 15 minutes. Dosages were applied 4 times over a period of 6 days. No ill effects were noted and gross pathology was negative (Fisher and Rosner 1959). In tests with rats and guinea pigs, exposure to a 10-percent *B. t.* preparation for 10 minutes produced no fatalities for the 1-week observation time. Dyspnea (discomfort) was noted, but recovery was rapid. The animals showed normal weight gain (Fisher and Rosner 1959). Five human volunteers inhaled 100 mg of *B. t.* powder daily for 5 days. Complete physical examinations before the test, immediately after the test, and 4 to 5 weeks later showed no abnormal conditions in the test subjects (Fisher and Rosner 1959).

Ocular irritation with *B. t.* was tested in albino rabbits. A dosage of 0.1 cc of a 20-percent suspension was instilled in each eye. One eye was rinsed immediately with isotonic saline. Six animals were tested. The eyes were examined immediately, after 3 hours and 24 hours, and every 24 hours until they appeared normal. Slight redness of the eyelids was noted at 3 and 24 hours. Eye irritation disappeared in 48 hours (Fisher and Rosner 1959).

NPV is an extremely specific virus, affecting only members of the insect Family Lymantriidae. It has been shown to have no effects on other vertebrate or invertebrate organisms.

It is highly unlikely that the use of *B.t.* or NPV as applied during gypsy moth suppression or eradication projects would pose a human health hazard.

INTEGRATED PEST MANAGEMENT

An IPM approach to gypsy moth management includes the integrated use of insecticides, parasite and predator management, the gypsy moth pheromone, release of sterile or partially sterile gypsy moth life stages, and forest stand manipulation. This approach provides a wider range of options in dealing with the gypsy moth problem by providing both short-term and long-term solutions; however, some of this technology still is in the developmental state.

Currently, only the biological and chemical insecticides are considered viable components for meeting the objectives of gypsy moth suppression projects. The use of forest stand manipulation, release of sterile or partially sterile gypsy moth life stages, and parasite or predator management need further field evaluation.

Eradication tools in addition to chemical pesticides are being developed. The unique nature of isolated infestations requires that eradication techniques be evaluated in this type of situation. This adds a degree of uncertainty in meeting eradication objectives since little efficacy data exists for some of the IPM components. Certain components have demonstrated population reduction potential, but several seasons may be necessary to achieve gypsy moth eradication objectives. *B. t.* was tested operationally in eradication projects for the first time in 1983 at 5 locations. Results, although preliminary, are encouraging. Additional experience has been gained with the use of *B. t.* in conjunction with mass trapping techniques in a similar number of locations. Similar results were obtained. This recent work was done with higher rates of *B. t.* (16 BIU per acre per application) than have been used in the past, and with as many as 3 aerial applications.

The biological effects of an IPM approach will depend on the extent to which the various components are used. An IPM approach encourages the selection of insecticides or other components on the basis of actual needs and management objectives. The biological effects of the registered insecticides as used in an IPM approach have been discussed in the chemical and biological insecticide alternatives section.

Parasites and predators play an integral role in the overall gypsy moth management strategy in generally infested areas. Since it is neither economically or environmentally feasible nor desirable to treat the entire infested area with insecticides, parasites and predators are relied on to reduce gypsy moth populations in areas that are not treated. In the treatment-area selection process, areas that support parasite or predator populations sufficient to maintain gypsy moth populations below damaging levels are not identified for insecticide treatment. Treatment is considered only in those high-use and high-value areas where the threat of excessive larval nuisance and host defoliation is immediate, and where parasites, predators, and disease agents are not exerting effective biological pressure on gypsy moth populations.

Manipulation of parasite or predator populations to levels that would exert significant pressure on gypsy moth populations to reduce larval nuisance and host defoliation or mortality entails the timely release of large numbers of laboratory-reared specimens. Since the gypsy moth was introduced into the United States, extensive efforts have been directed to the introduction of parasites and predators. To date, approximately 50 species have been imported from Europe and Asia with limited degrees of success. The primary problem in the manipulation of parasites and predators is to establish and maintain populations at levels that will contribute to effective biological control.

Grimble (1976) studied the effects of the release of an established larval parasite, *Apanteles melanoscelus* (Ratz.) (Braconidae), and a pupal parasite, *Brachymeria intermedia* (Nees)(Chalcidae), on gypsy moth populations in New York. He concluded that the release of *A. melanoscelus* failed to increase the levels of parasitism by that species. The inundative release of *B. intermedia* did cause a significant increase in parasitism but only within a 30-chain (0.375 mile) distance of the release points.

In 1982, two new parasites from India were introduced in Delaware. They are *A. flavicoxis* and *A. indiensis*, parasites of the Indian gypsy moth. There is no indication that either of these parasites is established.

Between 1973 and 1979, 15 species of exotic parasites and predators from France, India, Spain, Yugoslavia, Japan, and Morocco were released in Pennsylvania to supplement existing populations of

established parasites. Total project costs approached $1.5 million. By 1979, there was no evidence of any of these species becoming established. 3/

Since 1970, woodland study sites in New Jersey have been maintained to develop an understanding of gypsy moth population dynamics. During 1978, 402,047 parasites representing nine species were released in these sites. By 1979, a complex system of parasites appeared to be exerting biological pressures against the gypsy moth, one of the more significant parasites being Parasetigena silvestris (Robineau-Desvoidy). 4/

The gypsy moth sex pheromone, disparlure, has shown success in gypsy moth attraction and mating disruption strategies. The USDA and cooperating State agencies have successfully used disparlure-baited traps to delimit gypsy moth population boundaries and to identify isolated infestations. The attractive properties of disparlure make it an invaluable survey tool for locating predamaging gypsy moth populations.

Disparlure is registered by the EPA. It is recommended for use only in low-level populations to reduce the incidence of gypsy moth mating. The reduction of mating will subsequently reduce the number of egg masses laid, which will help to maintain gypsy moth populations below damaging levels. The registered product, Hercon Luretape®, is a disparlure-impregnated tape requiring manual application of forty 2-inch-square tapes per acre in a grid pattern. The registered application rate is 10 to 40 g active ingredient disparlure per acre. A second registered product by Hercon is a disparlure impregnated flake designed for aerial application at rates of 10 to 40 g/acre 5/.

The effectiveness of disparlure as a mating disruptant is density dependent. This means that the lower the level of infestation, the more

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3/ Robert A. Fusco, Pennsylvania Department of Environmental Resources, paper presented at Gypsy Moth Review, Columbus, Ohio, 1979.

4/ Letter from W.W. Metterhouse, N.J. Dep. Agric. to R.G. Doerner, NA, S&PF, USDA FS, dated July 30, 1979.

5/ Letter from A. R. Quisumbing, Health-Chem Corporation to Noel F. Schneeberger, NA, S&PF, USDA FS, dated November 2, 1983.

effective the pheromone, the heavier the infestation, the less effective the pheromone. Therefore, the level of infestation must be determined before treatment to ensure the greatest mating disruption.

The use of disparlure to meet the objectives of foliage protection, larval nuisance reduction, and total population suppression requires further investigation. In low-level, isolated populations like those treated in APHIS/State eradication projects, disparlure baited, high-capacity traps, when set in dense arrays, show some potential for gypsy moth control; however, populations must be at extremely low levels. In heavy populations as proposed for treatment in suppression projects, disparlure alone is not effective.

Disparlure may prove feasible to further reduce populations that have been suppressed with insecticides or another component of an IPM program to meet suppression or eradication project objectives. The effects of disparlure also may occur in the 2nd year after application if the material successfully reduced population levels. These techniques need to be further developed.

The use of forest stand manipulation to suppress gypsy moth populations in high-value forest stands has been suggested in the past. However, this method has not proven biologically effective. In suburban woodlands, stand manipulation is considered feasible to reduce gypsy moth impacts; less preferred hosts could be encouraged or even planted. Tree species that are less susceptible to gypsy moth defoliation include black walnut, white ash, catalpa, flowering dogwood, American holly, tulip-poplar, locust, sycamore, juniper, and balsam fir. In 1983, the USDA Forest Service initiated a research effort to study the use of silvicultural methods to control gypsy moth.

The release of large numbers of sterile or partially sterile male moths to reduce gypsy moth populations is a component of IPM. Research and development is continuing on the effectiveness of using sterile or partially sterile male moths to control gypsy moth populations. At the APHIS Otis Methods Development Laboratory, evaluations continue on refining male moth mass-rearing techniques and evaluating competitiveness of irradiated male moths A field test in which sterile male moths were used was performed in Michigan in 1980 and 1981. Monitoring of this site in 1982 and 1983 indicates that this

infestation is now eradicated. APHIS will monitor this site for 1 more season before assessing final results. Development of the sterile and partially sterile male moth technique is targeted for use in isolated infestations outside of the Northeast where the technique might be useful in an eradication strategy. There is no threat of human sterility should persons come into contact with sterile or partially sterile gypsy moth adults. Implementation of chemical and biological insecticides in an IPM approach may result in physical effects similar to those described under the chemical insecticide and biological insecticide alternatives. Implementation of parasite and predator management, the gypsy moth pheromone, and release of sterile or partially sterile male moths will not cause any adverse impact on the soil, water, or air in the treatment areas.

Forest stand manipulation through harvesting and thinning methods could entail favoring less susceptible trees by removing preferred hosts or even by planting less favored hosts. Such activity might result in some soil erosion and silting of adjacent streams. Soil disturbances are temporary and often last no more than 2 or 3 months depending on the time of the year.

An IPM approach favors the increased use of alternative means of suppression over chemical insecticides and the use of those methods of suppression that create minimal impact on the environment while meeting project objectives.

PUBLIC NOTIFICATION AND INVOLVEMENT

In accordance with the NEPA process, the USDA encourages public involvement in the development of gypsy moth suppression and eradication projects. Public notification procedures relevant to these projects include:

- Providing public notice of scoping activities.

- Making EIS and related documents available to inform those agencies, groups, and individuals who may be interested in or affected by proposed actions. Copies of this Draft EIS and the Final EIS can be obtained by contacting Thomas N. Schenarts, USDA Forest Service or Robert L. Williamson, USDA APHIS. Addresses and phone numbers are listed on the first page of this document.

In addition, State and Federal agencies that cooperate with USDA and the Forest Service will actively seek public participation and involvement at the local level. The purpose of this public involvement process is to:

(1) Explain the proposed action and its need.

(2) Discuss the consequences (if any) of the proposed action.

(3) Solicit identification of local issues and concerns so that appropriate mitigating measures can be developed.

(4) Stimulate discussion of alternative measures and their consequences.

(5) Guide the environmental analysis process.

For gypsy moth suppression activities on private land, residents can opt out of the proposed project. Because of the objective of eradication projects, residents do not have the option of having their property deleted from the proposed treatments. As previously discussed, mitigating measures will be employed to minimize the concerns of those residents who are unable to opt out of eradication projects.

Specific public participation and notification procedures relative to individual gypsy moth suppression and eradication projects will be developed during site-specific environmental analyses, and in accordance with NEPA.

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Acephate
Organophosphate insecticide; the active ingredient found in insecticide formulations sold under the trade name Orthene®.

Acetylcholine
A compound that is released at many automatic nerve endings. It is believed to function in the transmission of the nerve impulse.

Acetylcholinesterase
An enzyme released at nerve endings in order to accelerate hydrolysis of acetylcholine thereby ending nerve stimulation after an impulse has passed.

Active ingredient (AI)
The effective part of a pesticide formulation, or the actual amount of the technical material present in the formulation.

Acute toxicity
The toxicity of a compound when given in a single dose or in multiple doses over a period of 24 hours or less.

AI
Abbreviation for active ingredient.

APHIS
Animal and Plant Health Inspection Service. The USDA agency responsible for regulating materials which have potential for artificially moving gypsy moth out of quarantined areas and for eradicating isolated infestations of gypsy moth.

Apiary
A place where bees are kept. Bee hives.

Arthropods
Major group of invertebrate animals belonging to the phylum Arthropoda. This group includes insects, spiders and crustaceans.

Artificial spread
Term used to described the spread of gypsy by other than natural means; e.g. hitch-hiking insect stages on recreational vehicles, campers, cars, nursery stock, household goods, etc..

Bacillus thuringiensis
Scientific name of a bacterium that is pathogenic to the larval stage of many lepidopterous insects. The active ingredient in biological insecticides sold under such names as Dipel®, Bactospeine®, and Thuricide®.

B. t.
Abbreviation for *Bacillus thuringiensis*.

Buffer zones or areas
Usually set around sensitive areas such as lakes, streams or ponds that are not directly treated with insecticides; or areas set around the same, including people who object to chemical insecticides, that are treated instead with microbial insecticides such as B. t. or gypsy moth NPV. In some cases, may refer to areas actually treated, such as treatment of buffer zones along roads.

Caddisfly
A small moth-like insect. The larvae live in fresh water in portable cases they construct around themselves. Member of order Trichoptera.

Carbaryl
Carbamate insecticide; the active ingredient in insecticide formulations sold under the tradename Sevin®.

Carcinogenicity
Tendency of a substance to cause cancer.

Chitin
A semi-transparent horny substance forming the principal component of crustacean shells, insect exoskeletons and the cell walls of certain fungi.

Chitinase
An enzyme that hydrolyzes chitin.

Cholinesterase
See acetylcholinesterase.

Chronic toxicity
The effect of a compound on test animals when exposed to sublethal amounts continually. Usually daily exposures over a period of time: weeks, months or years.

Collembola
Springtails. Primitive, wingless group of insects commonly found in soil and duff.

Copepods
Usually, minute freshwater and marine crustaceans belonging to the order Copepoda.

Corixids
Group of aquatic insects, usually freshwater, that feed on algae and other minute aquatic organisms; belong to the family Corixidae.

Crustaceans
Large group of mostly aquatic arthropods belonging to the class crustacea and characterized by a chitinous or calcareous and chitinous exoskeleton. Members of this group include Copepods, water fleas, shrimps and wood lice, among others.

Cyclops
Scientific name (genus) of a group of Copepods.

DEIS
Draft Environmental Impact Statement

Diflubenzuron
The active ingredient of insecticide formulations sold under the trade name Dimilin®. Acts as a growth regulator by interfering with chitin synthesis and prevents gypsy moth from successfully completing their molting phases.

Dimilin W-25®
Commercial wettable powder formulation of diflubenzuron registered for use against gypsy moth.

Dipel®
Trade name of biological insecticide formulations containing the bacterium Bacillus thuringiensis.

Disparlure
Commercially synthesized female gypsy moth sex pheromone. Disparlure is used to disrupt mating by making it difficult for male moths to locate female moths.

Dosage rate
Quantity of a toxicant applied per unit area. Usually expressed as oz. or lbs. active ingredient per acre.

Dylox®
Trade name of chemical insecticide formulations containing the active ingredient trichlorfon.

EC_{50}
Median effective concentration; it is the concentration (ppm or ppb) of the toxicant in the environment (usually water) which produces a designated effect to 50 percent of the test organisms exposed.

EIS
Environmental Impact Statement.

Environmental analysis
Procedure defined by the National Environmental Policy Act of 1969 whereby the environmental impacts of a planned action (in this case gypsy moth suppression and eradication projects) are objectively reviewed.

EPA
U.S. Environmental Protection Agency.

Eradication projects
Projects whose objective is to eliminate gypsy moth infestations which were started as a result of artificial movement of gypsy moth life stages from generally infested areas.

Exclusion areas
Areas where product label prohibits the use of an insecticide, or areas identified during public involvement process as no-treatment areas.

FEIS
Final Environmental Impact Statement

Foliage protection
Tree foliage is considered to be prtected if the amount of defoliation that occurs is not severe enough to cause the tree to refoliate or produce a new set of leaves. Generally one of the major objectives in suppression projects.

Formulation
The form in which a pesticide is packaged or prepared for use.

Frass
Insect solid excrement.

FS
Forest Service. The USDA agency responsible for gypsy moth suppression projects.

Generally infested area or areas
That area, from Maine to northern Virginia and eastern West Virginia in which the gypsy moth is considered to be permanently established. Also includes an area in central Michigan in which gypsy moth is permanently established and where APHIS is no longer persuing eradication activities.

Gypchek
USDA laboratory prepared and refined gypsy moth NPV product. Used as a biological insecticide.

Half-life
The time required for half the amount of substance (such as an insecticide) in or introduced into a living system to be eliminated whether by excretion, metablic decomposition, or other natural process.

Hemiptera
True bugs. Group of insects with semi-toughened forewings and sucking mouth parts.

Hymenoptera
A large order of insects comprised of the ants, bees, sawflies and wasps. The typical adult each have four membranous wings and chewing type mouthparts.

Instar
The term for a insect before each of the molts (shedding of its skin) it must go through in order to increase in size. Upon hatching from its egg, the insect is in instar I and is so called until it molts, when it begins instar II, etc.

Invertebrate

Major group of animals of which arthropods are members; characterized by the lack of backbone and spinal column.

IPM

Integrated Pest Management.

Isolated or remote infestation

As pertains to gypsy moth, any infestation(s) occurring outside of generally infested area resulting from artificial spreadof insect life stages, as opposed to natural spread of the insect. Once established, isolated infestations may spread or expand naturally if they are not eradicated.

Larva (plural larvae)

An insect in the earliest stage of development, after it has hatched and before it changes into pupa; a caterpillar, maggot, or grub.

LC_{50}

Median lethal concentration as the concentration (ppm or ppb) of a toxicant in the environment (usually water) which kills 50 percent of the test organisms exposed.

LD_{50}

Median lethal dose, is the milligram of toxicant per kilogram of body weight (mg/kg) lethal to 50 percent of the test animals to which it is administered under the conditions of the experiment.

Lepidoptera

A large order of insects, including the butterflies and moths; characterized by four scale-covered wings and coiled sucking mouthparts.

Mg/kg/day

Milligrams per kilogram of body weight per day.

Mg/kg

Milligrams per kilogram; used to designate the amount of toxicant required per kilogram of body weight of test organisms to produce a designated effect; usually the amount necessary to kill 50 percent of the test animals. One mg/kg = 1 ppm. One mg = 0.000035 ounce, and 1 kg = 2.2 pounds.

Mutagenicity

The capacity of a substance to cause changes in genetic material.

Natural spread

Opposite of artificial spread; spread of gypsy moth through natural means, for example young larvae carried on the wind or older larvae walking to new food sources. Natural spread of gypsy moth occurs from generally infested areas, or from permanently established isolated infestations.

NEPA
National Environmental Policy Act of 1969, Public Law 91-190.

Notonectids
Group of predaceous aquatic insects belonging to the family Notonectidae. Commonly called backswimmers.

NPV
Nucleopolyhedrosis virus. In this case, naturally occurring virus specific to gypsy moth, and common in heavy gypsy moth populations. The active ingredient in the biological insecticide Gypchek.

Orthene®
Commercially produced chemical insecticide formulation containing the active ingredient acephate.

Parasite
Any animal that lives in, on, or at the expense of another.

Pheromone
As pertains to gypsy moth, chemical produced and emitted by female moths to attract male moths for mating.

Phytotoxic
Poisonous or harmful to plants.

Plecoptera
Stoneflies. Group of insects, the nymphs of which are aquatic and mostly phytophagous.

Ppb
Parts per billion; the number of parts of a substance in question per billion parts of a given material. One ppb = 1 ug/liter (water or air).

Ppm
Parts per million; the number of parts of a substance in question per million parts of a given material. (1 ounce of salt in 62,500 lbs of sugar). One ppm = 1 mg/kg (on a weight basis) = 1 mg/liter (water or air).

Predator
An animal that preys on others.

Pupa (plural pupae)
The immobile, transformation stage in the development of an insect that, as an adult, is completely different in its appearance compared to what it looked like when it hatched from its egg. Examples include beetles, flies, moths, and wasps.

Quarantine area(s)
See regulated area(s).

Refoliation

Term used to describe a new flush of leaves in mid-season. In gypsy moth projects, if a tree has to refoliate, then the objective of foliage protection was not achieved.

Regulated area(s)

Areas where gypsy moth is permanently established and reproducing, and from which APHIS regulates the movement of materials such as household goods, nursery stock, and other commodities in order to prevent artificial movement of gypsy moth life stages to infested areas of the United States.

Regulatory programs

As pertains to gypsy moth, APHIS programs designed to reduce artifical spread from regulated areas and to eradicate isolated infestations of gypsy moth.

Remote infestations

See isolated infestations.

RPAR

Rebuttable Presumption Against Registration. EPA process for reviewing and subsequently approving or withdrawing registration of pesticides.

Scoping Session or activities

As defined under the National Environmental Policy Act - an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This may include public meetings whereby significant issues are identified, or may simply be letters of inquiry to interested agencies, groups or individuals.

Sevin 4 Oil®

Commercial insecticide formulation containing the active ingredient carbaryl.

Sevin 80 S®, Sevin Sprayable®, Sevin XLR®

See Sevin 4 Oil.

Suppression projects

Projects administered by USDA Forest Service, in cooperation with State or Federal agencies, designed to relieve high gypsy moth populations in high-value high-use areas or to prevent tree mortality in forested areas. Also includes comparable projects on National Forest System lands.

Tachinidae

Family of flies, the larvae of which are parasitic.

Teratogenicity

The capacity of a substance to cause anatomical, physiological, or behavioral defects in animals exposed during embryonic development.

Thuricide®
Commercial biological insecticide formulation containing the active ingredient *Bacillus thuringiensis*.

Trichlorfon
Active ingredient found in chemical insecticide formulations sold under the tradename Dylox®.

USDA
United States Department of Agriculture.

USDI
United States Department of the Interior.

APPENDIX A

1983 SCOPING PROCESS: AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONTACTED

FOREST SERVICE

Director
Southeastern Forest Exp. Stn.
200 Weaver Boulevard
Asheville, NC 28804

Director
Southern Forest Experiment Stn.
U.S. Postal Service Bldg.
701 Loyola Avenue
New Orleans, LA 70113

APHIS

USDA, APHIS, PPQ
Regional Director - W
1 Hartford Square West
Building 1, Third Floor
Hartford, CT 06106

USDA, APHIS, PPQ
Area Director
Suite 503
80 Wolf Road
Albany, NY 12205

USDA, APHIS, PPQ
Area Director
Rural Route 6, Box 53
Wilmington, NC 28401

USDA, APHIS, PPQ
Area Director
William Green Federal Building
6th & Arch Streets, Room 9452
Philadelphia, PA 19106

USDA, APHIS, PPQ
Regional Director - NE
505 S. Lenola Road
Morrestown, NJ 08507

USDA, APHIS, PPQ
Area Director
1010 Jorie Blvd., Suite 38
Oak Brook, IL 60521

USDA, APHIS, PPQ
Area Director
915 Southwest Blvd., Suite K-2
Jefferson City, MO 65101

USDA, APHIS, PPQ
Area Director
3505 25th Avenue
P. O. Box 13
Gulfport, MS 39501

USDA, APHIS, PPQ
Regional Director - SE
P.O. Box 3659
Gulfport, MS 39503

USDA, APHIS, PPQ
Area Director
Brownett Bldg.
4080 Woodcock Drive, Suite 129
Jacksonville, FL 32207

USDA, APHIS, PPQ
FAA and NWS Building
P.O. Box 59 - 2647 AMF
Miami, FL 33159

USDA, APHIS, PPQ
Area Director
727 East Durango
Federal Building, Room B-201
San Antonio, TX 78206

USDA, APHIS, PPQ
Area Director
200 E. Nopal Street, Suite 208
Uvalde, TX 78801

USDA, APHIS, PPQ
Area Director
Room 2315, Intl. Arrl. Bldg.
J.F. Kennedy Intl. Airport
Jamaica, NY 11430

USDA, APHIS, PPQ
Regional Director - SE
Suite 400
2100 BoCA Chica Blvd.
Brownsville, TX 78521

USDA, APHIS, PPQ
Area Director
Room 205, Towers Royale
520 Old Spanish Trail
Slidell, LA 70458

Regional Director - W
USDA, APHIS, PPQ
620 Central Avenue
Building 2B, Room 103
Alameda, CA 94501

USDA, APHIS, PPQ
Area Director
3112 Federal Building
Seattle, WA 98174

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APHIS - continued

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Phoenix, AZ 85004

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Area Director
40 S. Gay Street, Room 419
Baltimore, MD 21202

USDA, APHIS, PPQ
Area Director
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Honolulu, HI 96850

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26 Federal Plaza
Room 1747
New York, NY 11430

EPA

EIS Review Coordinator, R IV 14
Environmental Protection Agency
1421 Peachtree Street, NE
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EIS Review Coordinator, R VI 14
Environmental Protection Agency
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NATIONAL PARK SERVICE

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Mr. Stephen D. Bean, Forester
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APPENDIX C

REVIEW OF EXPERIMENTAL EVIDENCE ON THE MUTAGENICITY OF N-NITROSOCARBARYL

Retyped verbatim from the Carbaryl Decision Document,
December 1980.
U.S. Environmental Protection Agency

REVIEW OF EXPERIMENTAL EVIDENCE ON THE MUTAGENICITY OF N-NITROSOCARBARYL

Carbaryl has been shown in vitro to react with sodium nitrite under acidic conditions (pH 1) to form N-nitrosocarbaryl (Eisenbrand et al., 1974). Because nitrite is present in human saliva and food products, the formation of nitrosocarbaryl in stomach physiology is possible, in view of the widespread use of carbaryl. Rickard (1979) demonstrated the in vitro formation of nitrosocarbaryl in the stomach of rats and guinea pigs. When guinea pigs were given either simultaneous intubation of carbaryl (1 umol) and sodium nitrite (1160 umol), or when these components were mixed with feed, approximately a 1.5 percent yield of nitrosocarbaryl was detected. The formation of this nitroso derivative was dependent on the amount of nitrite and the pH, and not particularly by the amount of carbaryl present. Increasing the amount of carbaryl from 0.025 to 2.5 umol did not increase the yield of the nitroso compound. In rats, the stomach pH (3.5-5.5) is higher than in guinea pigs (pH 1.5), and in that species a very low yield of nitrosocarbaryl was found (0.02 percent) at the same concentrations of nitrite and carbaryl.

Nitrosocarbaryl has been shown to be strongly mutagenic in bacteria. Blevins et al. (1977) found that the base-pair substitution sensitive *Salmonella* strains TA 100 and TA 1535 were reverted by this without metabolic activation. The reversion frequency in TA 100 was increased by approximately 1.6-fold at 1.15 ug/plate and 6-fold at 11.5 ug/plate, and TA 1535 by about 3-fold at 76-fold at 11.5 ug/plate. Nitrosocarbaryl was not as active on the frameshift sensitive strains TA 98, TA 1537, and TA 1538. Marshall et al. (1976) found that nitrosocarbaryl increased the number of histidine-independent colonies of TA 1535 by approximately 6-fold at 0.5 ug/plate and by 367-fold at 50 ug/plate without metabolic activation. Marshall et al. also found nitrosocarbaryl to be slightly active (above 6-fold over background values) on the frameshift sensitive strains TA 1537 and TA 1538 at 50 ug/plate. Both Blevins et al. (1977) and Marshall et al. (1976) found that the mutagenic activity of nitrosocarbaryl was dose-related.

Elespuru and coworkers (1974) measured the induction to novobiocin resistance in *Haemophilus influenzae*. These authors found that nitrosocarbaryl was approximately an order of magnitude more potent than the mutagen N-methyl-N'-nitrosoguanidine (MNNG). In *Escherichia coli* nitrosocarbaryl was also more potent in the induction to arginine prototrophy than MNNG (Elespuru et al., 1974). Uchiyama et al. (1975) found mutagenic activity as tested by the ability to cause reversion at the tryptophan locus in *Escherichia coli* (data not quantitated).

Generally, metabolic activation was not required for the mutagenic response of nitrosocarbaryl. For example, when Marshall et al. (1977) incorporated the S-9 fraction in the *Salmonella* assay, a decrease in mutagenic activity was observed. Greim et al. (1977), however, found an increase in mutagenicity after metabolic activation by mouse-liver microsomes.

Siebert and Eisenbrand (1974) reported that nitrosocarbaryl was active in causing mitotic gene conversion in *Saccaharomyces cerevisiae*. Incubation for 2 hours on 1 ppm of nitrosocarbaryl increased the relative conversion frequency 3-fold for the *ade*-2 locus and 5-fold for the *trp*-5 locus, and at 30 ppm increases were 139-fold for the *ade*-2 locus and 885-fold for the *trp*-5 locus. In this study, a dose-related effect was shown using 5 concentrations of nitrosocarbaryl. Regan et al. (1976) demonstrated that nitrosocarbaryl was able to induce DNA damage in culture human cells as measured by unscheduled DNA synthesis. In addition, by using methyl labeled [^{14}C] and ring labeled [^{3}H] nitrosocarbaryl, Regan et al. (1976) found that the ^{14}C label was associated with cellular DNA, whereas the ^{3}H label was not. Because nitrosocarbaryl has been observed to cause reversion of base-pair substitution sensitive strains (TA 100, TA 1535), these results suggest that the nitrosocarbaryl molecule was split and the resultant methyl group could alkylate DNA and cause base-pair substitution type mutations.

Ishidate and Odashima (1977) reported several chromosome aberrations (80 percent aberrant cells) in Chinese hamster cells 24 hours after exposure to nitrosocarbaryl (0.015 mg/ml). The toxicity of nitrosocarbaryl was not reported.

APPENDIX D

EPA CARBARYL DECISION DOCUMENT, DECEMBER 1980: SUMMARY OF CONCLUSIONS

CARBARYL DECISION DOCUMENT, DECEMBER 1980
Office of Pesticides & Toxic Substances
Environmental Protection Agency
401 M Street SW
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A. Summary of Conclusions*

1. Teratogenic and Fetotoxic Effects. Based on the weight of evidence of currently available studies which are valid and interpretable, the Agency has concluded that a rebuttable presumption on the basis of carbaryl-related teratogenic and fetotoxic effects is not warranted at this time. In the Agency's judgment, the extremely high doses of carbaryl used to elicit effects in the developing organism, coupled with the positive correlation of maternal and fetal toxicity in the multiple species tested (the dog being a possible exception), do not indicate that the pesticide carbaryl constitutes a potential human teratogenic or reproductive hazard under proper environmental usage. However, the Agency is considering whether another study in dogs should be conducted, with special attention paid to sufficient numbers of animals in the dose groups, the condition of the bitches throughout the period of dosing, and maternal and fetal blood levels of the compound.

2. Mutagenic Effects. Based on the weight of extensive existing evidence, the Agency has determined that the current data base does not support a conclusion that carbaryl poses a mutagenic hazard to humans. Due to the weak mutagenic responses which have measured, and due to the suggestive rather than conclusive nature of the evidence available as to the potential of carbaryl to reach the mammalian germinal tissues, the Agency believes that general exposure-reduction measures typical of those already on many of the labels, are appropriate and will be pursued prior to any further RPAR review. A rebuttable presumption on the basis of carbaryl-related mutagenic effects is therefore not warranted at this time.

3. Oncogenic Effects. Based on the weight of existing evidence, the Agency has concluded that the current data base does not indicate that carbaryl poses on oncogenic hazard to humans. A rebuttable presumption on the basis of carbaryl-related oncogenic effects is therefore not warranted at this time.

4. Neurotoxicity. Based on available evidence, the Agency has concluded that carbaryl does not pose a human health hazard in terms of neurotoxic effects. A rebuttable presumption on the basis of neurotoxicity is therefore not warranted at this time.

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* From: With oral approval from EPA, retyped verbatim in order to produce a clear copy.

5. Viral Enhancement. The Agency's determination at this juncture is that research into viral enhancement as a possible adverse effect of exposure to carbaryl is preliminary in nature and that current information does not constitute a basis on which to conclude that carbaryl poses a human hazard in this area. A rebuttable presumption on the basis of viral enhancement is therefore not warranted at this time.

6. Overview--Determining Considerations. Recognizing that the data base on any chemical is necessarily a continuum, the Agency's determination not to proceed with an RPAR action against carbaryl at this time takes into account a number of considerations in connection with the present toxicological picture of the pesticide. As has been pointed out, the current data base under review is extensive, more extensive than has ordinarily been the case for pesticides which have come under Agency review. This is particularly true for teratogenicity/fetotoxicity and mutagenicity, which are the toxicological areas of primary concern, and it is unlikely that resource-intensive RPAR procedures would surface data not already in the Agency's possession via other channels.

Although the current data base is extensive, risk data are not unequivocal, and study results, again in the areas of teratogenicity/fetotoxicity and mutagenicity, have been inconsistent. The current toxicological picture of carbaryl thus reflects a degree of uncertainty. It is in the face of such uncertainty that the Agency must determine whether or not to proceed with an RPAR action and the detailed risk/benefit analysis the RPAR process is intended to implement. In the case of carbaryl, consideration of the overall weight of current evidence leads the Agency to conclude that the responsible call is not to initiate RPAR proceedings at this juncture but rather to address the concerns at issue via the recommendations made below. Should further review data indicate that current use patterns of the pesticide pose unreasonable adverse effects to human health or the environment, however, the Agency will re-open the case of carbaryl as an RPAR candidate.

B. Recommendations

Because the Agency has concluded that a rebuttable presumption against registration and continued registration of pesticide products containing carbaryl is not warranted at this time, the Agency's recommendation is that carbaryl be returned to the registration process. This recommendation is made with the following stipulations: 1) that a FIFRA sec. 3(c) (2) (B) action be considered for additional data on the effects of carbaryl, possible including another study of the teratogenic and fetotoxic effects of carbaryl in dogs 2) that appropriate label changes be implemented according the forthcoming negotiations between the Agency and registrants to ensure that exposure is minimized.